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VILLAGE ON THE CONGO RIVER.

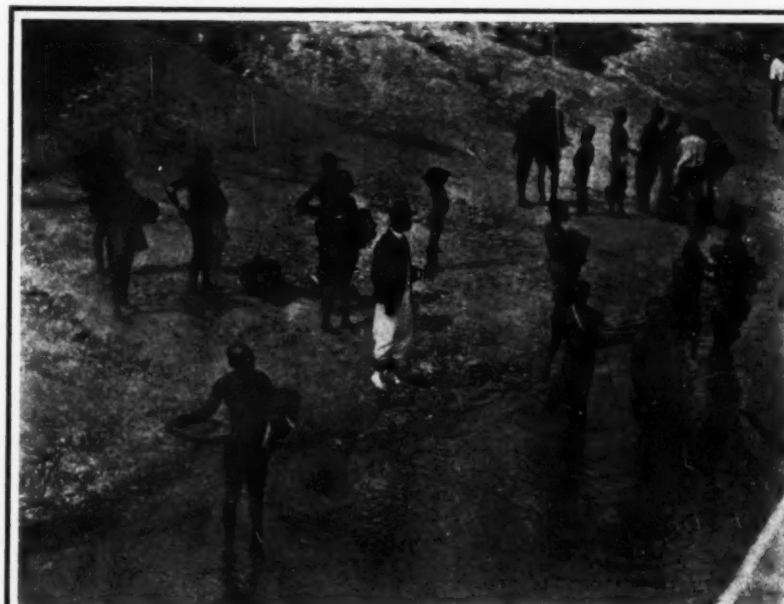
The dots on the palm leaves are nests of the weaver birds. Flat and bare land shows where the river has eaten into and overflowed the shore.

A RESTHOUSE AT BAFWASIKULE.

Erected for the agents of the colony. The courtesy of these roadhouses has everywhere been granted to the expedition.

MOBALI WOMAN CARRYING WATER. MOBALI WOMAN CARRYING FIREWOOD.

The Congo natives (Bantus) are sharply cut off from the other five African races by their language which, built on a systematic, philosophical basis, would seem to argue degradation from some superior race.



BARTERING WITH PASSENGERS ON THE RIVER BOAT.

Congo natives are great traders, using for currency such objects as beads and brass rods.

REVISING THE LOADS. TWO HOURS FROM AVAKUBI.

The 200 porters and native assistants of the Congo expedition after marching through the dense forest for 22 days.

AT THE ENTRANCE OF THE "DENSE FOREST."

The mightiest primeval woods known to man. A cold gray picture is wholly inadequate to make vivid a tropical country, the splendid color, the sounds, the life and the heat.

IN THE HEART OF AFRICA.—[SEE PAGE 360.]

SILENCER FOR MILITARY RIFLES.

SOME EARLY INVESTIGATIONS ON SOUND DEADENING.

BY J. P. FARLEY. UNITED STATES ARMY.

According to a recent issue of the New York Times, the Maxim silencer is a pronounced success, and orders have been placed by the Ordnance Bureau of the War Department for over one thousand of this device to be issued for experimental purposes to the several arms of service.

Without claiming for this device the property of complete silencing or deadening sound, it appears that something near about fifty per cent of the report of discharge from a small arm rifle is neutralized or destroyed, while the flash of discharge disappears almost, if not altogether, where the silencer is employed.

Advantages incident to diminished recoil and shock effect are referred to as conducive to improved accuracy.

Quoting from the article referred to in the Times it will be seen: "That with the silencer a half dozen men of high class, knowing the distance, and under ordinary conditions, should be able to put a battery of artillery out of business in about two minutes at a full 2,000 yards, and it would be a very curious sort of a situation which could ever prevent a half dozen men getting up individually within that distance of any field artillery.

"There is not the least reason in the world why an individual sharp-shooter should not be able to lie down anywhere from 1,000 to 2,000 yards and pick off as many officers and men working guns as he cares to. Nor would he ever be discovered until an enemy happened to advance over the exact ground upon which he lay. If he used his eyes he could avoid even that contingency."

What has been the evolution of this idea of invisibility and noiselessness in small arms? To Mr. Maxim is due the sole credit of its development or practical application, and here I may say that for one I saw this thing coming on as long ago as the summer of 1875. The late Colonel James G. Benton, of the Ordnance Department, U. S. A., with whom I was serving, directed me, as his assistant at the National Armory, to make certain experiments undertaken in consequence of observations made by Quartermaster-General M. C. Meigs, U. S. A., during his tour in Europe.

He had witnessed promising results with rifles but partially rifled, so-called "muzzle-rifling," whereby a smoothbore gun with a muzzle-piece might be converted at pleasure to a fairly good rifle.

While engaged in experiments bearing upon this matter, I lengthened as well as shortened the service rifle barrel, caliber .45, and when employing the service charge of powder (70 grains) and the service bullet, at that time 405 grains, it became manifest in the course of experiment that a large proportion of the black powder charge for service length of barrel (32 inches) was not consumed in the barrel, and only a fraction of the work, therefore, was done upon the bullet, that was expected. To gain then the full effectiveness of the powder charge it became necessary to lengthen the barrel by gradual process until a maximum length of some 120 inches was attained, and a muzzle velocity of some 1,700 feet second secured, as against but 1,260 feet second, where the powder was but partially consumed, as for the normal 32 inches in length of barrel.*

Of course, no thought was had at the time of carrying the service length of barrel to such extremity save in this.

I reported to Colonel Benton that I had discovered the property of absolute smokelessness in the powder, together with comparative noiselessness in the gun, and gave it as my firm conviction and decided opinion that a weapon could be devised to be placed on a tripod or wheels which, when used by a special corps of men, would be troublesome in the extreme for an adversary, the gun to be used on the picket or skirmish line, and if so desired, by sharp-shooters.

In my official report, published in Ordnance Notes, No. 38, dated National Armory, April 2nd, 1875, the following appears:

"It was noticeable that when the long barrels, .45 caliber, were fired (four barrel lengths, 120 inches), the smoke almost, if not entirely, disappeared, a small quantity of black dust, as it were issuing from the muzzle in lieu of the voluminous body of white smoke incident to service conditions. The report of discharge in the case of the long barrel was much deadened."

Here then, as long ago as 1875, was the first distinct approach to a rifle that should be invisible to the enemy, the black powder converting in fact to a true smokeless powder, and this long before nitro-compounds or so-called smokeless powders came into use. Here also and for the first time was presented what might now be regarded as the legitimate conclusion of the argument—a noiseless and an invisible gun.

The absurdity is manifest of regarding noiselessness in a military weapon in a criminal or ante-humanitarian light, where invisibility, due to lack of smoke, is passed over lightly, and this too in the face of the deadly execution due to smokeless invisibility in the South African war.

Imbued then, as I have been for many years, with the result of my accidental discovery at the armory, I have looked forward to the day—now about to arrive—when absolute invisibility in the weapon shall be achieved and noiselessness in large degree accomplished. The files of the Ordnance Bureau, U. S. A., bear evidence of my attempts to have a special rifle of small caliber constructed, of length sufficient to deaden the noise of discharge, but this without avail, my scheme being regarded as somewhat chimerical. I was brought to think very seriously on this subject of noiselessness by a letter addressed to me in 1900 from the editor of the Army and Navy Journal while I commanded the Watervliet Arsenal and Gun Factory. A gentleman of Pittsburg, Pa., John E. Bissell, claimed that he could build a noiseless gun, so far as explosion is concerned, in which water, oil, alcohol, or any liquid could be used as the expelling medium for the projectile. This proposition met with no encouragement at my hands, but my superintendent, Mr. Christiansen, master mechanic of the gun shops, at my suggestion, devised a cut-off or valve, which he claimed might operate to bottle up the gas, and in this manner deaden the sound of discharge.

Mr. Maxim and Mr. Christiansen were then working on different lines from myself, as I had gone no further than to propose an added length of barrel, the extra length to be fixed as a reducer of shock effect on the atmosphere by the blow of escaping gases as well as the reactionary effect of collapse of the hemisphere of gas which forms behind the smoke and in front of the muzzle.

My specific desire (officially expressed) was, at say about 16 inches from the bottom of the bore of a .30 caliber rifle, to add a length to the barrel in which the grooves could be deepened or better still, eliminated, the forward section of the barrel being vented so as to whistle off the gases instead of permitting them to strike the air with a sharp thud.

Noiselessness is not a thing *per se* as relates to a military weapon. The term must be used only in a comparative sense, just as we speak of smokelessness in powder; and let it not be forgotten that in one of the Eastern conflicts four hundred Russian field guns with all their accessories were practically placed *hors de combat* by being entirely exposed and under fire of three hundred guns of the Japanese army, which were secreted, and could neither be seen nor heard. They could not be heard by the Russians because of the din of bursting shell and shrapnel overhead and because of the noise the Russians were making with their own guns, in the vain endeavor to hit something they knew not what. Neither to be seen nor heard on the field of battle is then the legitimate conclusion of the argument of to-day; and *when being heard is so far regulated as not to betray the firer's position the problem for the occasion, at least, is solved. This was often the case, both in the South African and the Eastern conflicts.*

At the risk perhaps of taxing the patience of the reader I may here enter some of the data derived under instruction of the Chief of Ordnance and from his office in answer to my request that the long barrel theory be exploited.

Frictional resistance of the bullet in the bore when the barrel is lengthened is the most uncertain element entering the problem.

Data are at hand for the determination of these resistances and are contained in the Reports of the Chief of Ordnance, 1904 and 1905.

Some notion of deep grooving on these resistances may also be gleaned from certain experiments made at the Springfield Armory with a deep grooved barrel. In these experiments the grooves of the service rifle were deepened .005 inch on the diameter over the last 14 inches of travel. This deepening resulted in a muzzle velocity of 2,256 feet seconds for the same cartridge which gave 2,200 feet seconds in the service barrel. This is equivalent to a total constant pressure of about 104 pounds or about 1,420 pounds per square inch over the travel named. From the other experiments it was found that the average pressure necessary to force a .30 caliber service bullet through the service barrel (new) was 886 pounds over the entire travel, or 12,047 pounds per square inch. In a worn or eroded barrel this pressure is much higher and very irregular; so much so, that it is believed that effect of length of cylindrical bearing is justifiably omitted in the figure 886, quoted above; for in the average barrel more or less erosion will be present.

The first steps taken in the study were to ascertain the true powder pressures in the bore of the service barrel with the model of 1906 cartridge, and then to extend this curve of pressure beyond the muzzle to the point of zero pressure, viz.:

(1) The velocities of the bullet in the bore as a function of space.

(2) The pressures in the bore as a function of space.

(3) The pressures in the bore were then computed as a function of time; the mean integral of this curve was obtained and substituted in the expression $F = M\frac{d^2s}{dt^2}$ which was then integrated and the result showed that the pressures computed correspond only to the inertia of the bullet as regards rectilinear translation.

(4) The resistance corresponding to the rotational inertia of the bullet as a function of space.

(5) The resistance corresponding to the friction due to the thrust of the lands to give rotation, as a function of space.

(6) The frictional resistance of the bullet to translation through the bore assumed at 886 pounds total.

(7) A resultant pressure curve was then computed as a function of space and plotted.

(8) The total potential work in the powder charge was then computed.

(9) The work done by the powder up to the service muzzle was next computed.

(10) The result obtained in (9) was subtracted from the resulted obtained in (8) and the result gave the total potential work left in the powder gases at the service muzzle.

(11) Assuming perfect adiabatic expansion and obturation, the result obtained in (10) plus the kinetic energy in the bullet was equated with the resistances beyond the muzzle over a path x—and the relation solved for x. This gave x equal to about 100 inches when x is measured from the origin of travel.

(12) The resultant pressure curve beyond the service muzzle was then drawn in by trial so that it would become tangent to the axis of travel at $x=100$ inches and so that it would include beneath it an area corresponding to the potental work left in the powder gases at the service muzzle.

(13) The velocities of the projectile beyond the service muzzle were then computed by steps up to the point where $x=100$ inches when the velocity of course became zero.

The next step undertook to ascertain what muzzle velocity could be had if a barrel of reasonable length

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* It should be understood that this 1,700 f. s. initial velocity is due *solely* to increment in length of barrel and more thorough consumption of powder charge in the barrel.

The experiments referred to had for their final object the determination of the laws governing in the matter of velocities for every variation in length of barrel—weight of bullet and weight of powder charge—the limits for barrel length being five (5) inches on the one hand and one hundred and twenty (120) on the other. For bullet weight ten (10) grains and one hundred and twenty (120), while the weight of bullet ran from two hundred (200) grains (the pistol bullet caliber .45) to eight hundred grains.

The Quartermaster-General, U. S. A., at whose instance these experiments were inaugurated, indorses the official report in the following words:

Allow me to compliment your Corps and Captain Farley particularly upon the admirable and interesting series of experiments so well reported and presented in Ordnance Notes No. XXXVIII, which I have read. The subject is one of almost universal scientific interest and the results are valuable. I know of no series of experiments on this subject approaching these in completeness, in accuracy or in value. Their conduct, and the complete manner in which the results are reported and presented, deserves the highest credit.

Very truly yours,
M. C. Meigs,
Quartermaster-General, U. S. A.

Gen. Crozier, Chief of Ordnance, U. S. A., at my request, directed the computations and deductions in the paper to be made relating to the length of and the venting of barrels for the purpose of deterring the effect on velocity of projectile. My present effort will be bent upon some practical test of any and all combinations to reduce the noise of discharge, and it will be brought before the Chief of Ordnance for consideration and for test.

The Moore Silencer is a spiral head or tube vented through to permit the gradual escape of gas, and it is in principle the same as that I have had in view for many years.

were used and vented over a path sufficiently long to give reasonable assurance that the powder gases would all be expelled by the time the bullet left the muzzle. Venting from a point corresponding to 16 inches of travel and assuming that the vents could be made of such section as to cause the resultant pressure curve to become rectilinear from the 16 inches point and to cross the axis of travel at any assumed muzzle, several lengths of travel were tried with the following approximate results:

50 inches travel	M.V. = 2,645 f. s.
44 inches travel	M.V. = 2,585 f. s.
40 inches travel	M.V. = 2,596 f. s.

The final step taken was to ascertain approximately whether all of the powder gases would be expelled through the vents before the bullet passed the assumed muzzles. As the successive sections of the vents necessary to give the rectilinear resultant pressure curve over the vented travel were unknown, the only computation made was that of ascertaining whether the mean resultant pressure over the vented travel was sufficient to translate the mass of the powder charge over 8 inches plus the vented travel in the time required by the bullet to pass over the latter space. The value of the constant used in the integration for the determination of this point was one-half the velocity of the bullet at the 16 inches point. The results of these calculations indicated that the gases would all be expelled in each case assumed except the last—friction of gases in vents being disregarded.

The results stated above cannot, of course, be held to be rigid, since the calculations are based on assumptions, some of which are as yet untested, and others, such as perfect adiabatic expansion, are known to be but approximate.

Now that this subject has come into general notice it will no doubt be thoroughly threshed out by experiment. I hope to learn from such tests what may result from my idea of whistling off the gas of a small arm rifle instead of the present method of letting it go with a bang. Some noise there of course must be in noiseless guns just as there is some smoke in smokeless powders. All things in this world are comparative, and the question must resolve itself into this, What are the comparative advantages and disadvantages of a noisy gun and one less noisy, of a smoky powder and one less smoky? All this we have yet to learn; the questions as yet remain unanswered.

AEROPLANE ACCIDENTS.

RECORD-BREAKING AND ITS CONSEQUENCES.

THAT the number of deaths in connection with aeroplaning during the past summer has been enormous in proportion to the number of people who fly is a matter as to which there is, unfortunately, no doubt whatever. Almost every week, and often, in fact, several times a week, there have been notices of accidents to aeroplanes involving fatal results to the aviator. That every new development in mechanics involves some risk is obvious, and there are few instances of progress which have not been accompanied with a certain toll of human life. In the case of aeroplanes, however, this toll has been excessive, and it is quite clear that the movement cannot be of any practical use if the loss of life so far incurred represents in any way approximately the necessary risk.

In reviewing both the accidents and the general character of the movement up to date, however, there are several points which strike one as indicating a strong difference between the development of aviation and any other form of mechanical progress. The first is, that up to the present almost the sole use to which the aeroplane has been put is exhibition flights; and the second, that nearly all the fatal accidents happen on the Continent. It is true that Lieut. Selfridge was killed in the United States, and also that the Hon. C. S. Rolls lost his life in England, but, with these exceptions, practically all the fatal accidents have been Continental.

While the accidents have principally been on the Continent, the "records" have also been principally made there, and this leads to the consideration of whether the accidents are the result of the attempts at records, and whether the making of records is the best way of furthering the progress of flight. In fact, this points to the whole consideration of the position of flight in England and on the Continent.

There can be no doubt that the endeavor to improve on previous performances has a beneficial effect, provided that the performances are under actual working conditions. Thus, if we examine the history of the progress of any branch of mechanics we find it consists simply of an endeavor to improve on previous performances. We can see this very well in the case of steamships. The constant endeavor of the passenger steamship lines, for instance, is to reduce the length of passage, and each reduction in time, provided that it is done without sacrificing seaworthiness, reliability, etc., is a distinct improvement. When we come to the making of records by special machines built for the purpose, however, we get to a very different state of things. Thus, if seaworthiness, durability, and safety are sufficiently sacrificed, speeds can be got far above those which can be obtained from a boat which is of any practical use. In fact, the speed obtained depends solely on the extent to which practical requirements are sacrificed, and the risk which those in the vessel are willing to take. "Progress" along these lines is simply movement in the wrong direction, and does not in any way contribute to the development of useful machines. In the large majority of the branches of engineering no attempt whatever is made to create such records, but where they have been made they have had no effect whatever on the progress of practical engineering. Thus the fastest steamboats in proportion to their size which have ever been built are probably the racing steam launches built for some of the American millionaires, but their construction has had no effect whatever on the construction of practical steamships.

What is true of ships is true also of aeroplanes and everything else. Records can only be got by cutting down the factor of safety; sensational performances can only be made by taking risks. Given that the makers of aeroplanes require sensational performances as an advertisement, there is no difficulty in getting men to take practically any risk for the sake of the rewards offered. The position is in fact exactly the same in this case as in that of an entertainment which requires men to do risky performances on a tightrope or in any other similar way, and the results are useless. Obviously, however, if performances are attempts of which the whole point is that they are sensational and risky, there will be numerous accidents.

What is required to make the aeroplane take its place as one of the practical means of locomotion in the world is general confidence in its safety, and the result of all these attempts at records, with their accompaniment of accidents, is having exactly the opposite effect.

As has been said, the striving after records has been carried a great deal further on the Continent than here, but in view of the fact that there have been such an enormous number of accidents as a result, we may fairly consider that the position of flight here is as promising. Flights round Brooklands and at similar places are not as sensational as flights across the Alps, but there is probably more of scientific interest to be learned from them. Again, the strife for records means that flights are seldom attempted except in calm weather, while, in England at all events, flight will be of little use till it is a certainty in all reasonable weather. In this we appear to be well holding our own, and at the Bournemouth meeting English aviators showed that they were at least as much at home in a wind as any of their competitors from the Continent.—Engineering.

AN INGENIOUS WAY OF EXAMINING THE CONTENTS OF THE DUODENUM.

THE lay mind is apt to consider the advances made in surgery in the last decade of more importance than those in modern medicinal practice. That this popular impression is erroneous is proved by the many devices which have of late years been put to successful tests to enable a physician to examine with the greatest accuracy the workings of inner organs and to restore them to their normal condition without resorting to the surgeon's knife. Notable forward strides in this direction have been made in the study of the digestive organs of the human body, such as examination of the stomach and its contents by the use of a bucket firmly held at the end of a fine cable and let down into the stomach, to fill and be hauled up again for examination by chemical reaction tests, to determine whether the stomach digests normally or abnormally, and thus to enable the physician to diagnose correctly the defects or diseases of the digestive organ.

From the New York Medical Journal we learn that Dr. Max Einhorn, professor of medicine at the New York Post-Graduate Medical School, has succeeded in obtaining samples of the chyme contained in the duodenum by the use of a very simple apparatus called the "digestive juice aspirator," a portion of which instrument is introduced into the duodenum by way of the esophagus and stomach without the slightest discomfort to the patient.

It is well known that primary digestion takes place in the stomach, but the most important digestive action takes place in the duodenum, that is, the part into which the stomach discharges by way of the pylorus, and which also receives the very important secretions from the liver (bile) and the pancreas.

For the purpose mentioned, Dr. Einhorn uses a thin flexible tube terminating in a small metallic perforated capsule, which is swallowed by the patient and passes into the stomach, dragging the flexible tube along in its descent, the tube being sufficiently long to extend a distance out of the patient's mouth.

The capsule in the stomach is acted on by the movement of the stomach wall, as in the case of food. In the course of about an hour it passes by way of the pylorus into the duodenum, and even as far down as the beginning of the small intestine. The outer end of the tube is then connected with a small hand suction pump, the piston of which is gradually withdrawn, so that the duodenal contents are drawn into the perforated capsule and up through the tube into the glass barrel of the pump, which latter is now disconnected from the tube and its contents emptied into a vial for examination. The tube and the capsule attached thereto are then withdrawn.

The immense importance of being able to obtain the chyme directly from the duodenum, especially the lower part thereof, is apparent, as the physician by the subsequent tests made of the chyme obtained, can diagnose accurately and readily determine the proper or improper functioning of the duodenum. The same instrument can, of course, also be used in the stomach, to obtain samples of gastric secretions, during the entire period of stomach digestion, from beginning to end.

The successful use of the simple device described has led Dr. Einhorn to its reverse use, that is, introducing food or medicine directly into the duodenum without first passing it into the stomach in the ordinary way of swallowing the food or medicine. In this case, the food or medicine in liquid form is filled into the barrel of the pump and after the introduction of the perforated capsule into the duodenum, as above described, the pump is attached to the outer end of the tube, and the pump is actuated by hand to force the food or medicine through the tube and perforated capsule directly into the duodenum. This treatment has been successfully used in several cases.

FLOUR.

FALSIFICATION of flour is attempted from time to time in France, and this was tried not long ago on a large scale by the use of talc. More recently, we have the substance known as "blanc flour," which appears to be of English origin, and it has been recently used to adulterate flour in France. Although it was claimed to be a harmless product and one which contained many of the principles found in wheat, an analysis which M. Curtel, director of the Dijon laboratory, made of it shows that it is simply a mixture of phosphates of lime containing their usual impurities such as oxides of iron and aluminium, silica and organic matter. The proportion of phosphoric acid is about the same as for wheat. M. Curtel formed a good method for detecting the presence of this adulterant in flour. He agitates 5 grammes of flour with 40 to 50 cubic centimeters (2.44 to 3.05 cubic inches) of tetrachloride of carbon, then centrifugating and separating the tetrachloride and the flour from the deposit which is formed. This deposit is dissolved in dilute nitric acid, and we detect the presence of the impurities by the fact that molybdate of ammonia gives with the preceding an abundant precipitate of phosphomolybdate. Such will not occur with pure flour, as this gives but a small amount of natural impurities as a deposit. In the case of bread, he also succeeds in detecting the adulterant. The bread, in fine dry powder, is boiled with the tetrachloride, and the impurities are thus thrown down, when we operate as above. It is curious to note that the new adulterant gives a whiter bread and also increases the yield.

WIRELESS TELEGRAPHY AND TELEPHONY.—II.*

A REVIEW OF ETHEREAL SIGNALING METHODS.

BY CORNELIUS D. EHRET.

Concluded from Supplement No. 1821, page 342.

In Fig. 12 is illustrated a late development in wireless detectors. It is known as the "silicon" receiver and is accredited to Mr. Pickard. The silicon used is not a compound of silicon, but simply silicon, which is a black mass capable of taking a polish. The mass of silicon, *N*, is engaged by a brass or other conducting

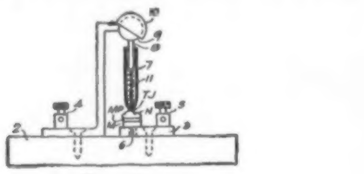


Fig. 12.

finger or rod, spring pressed. The silicon and the engaging conductor form a thermo-electric couple capable of producing a small electric current when heated. The faint high-frequency electric currents, due to the electric waves transmitted through space, pass through the thermo-junction, heating the same, and the couple then produces a current passed through

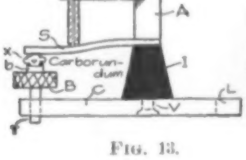


Fig. 13.

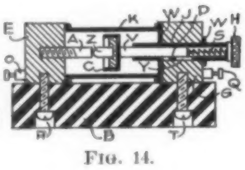


Fig. 14.

the telephone or other instrument, causing a click or sound in it. Here again is a detector which requires no local battery, a thing which was conspicuously necessary with the earlier detectors; also with the Pupin and Fessenden or Vreeland detectors. The silicon detector is also considered as a solid rectifying

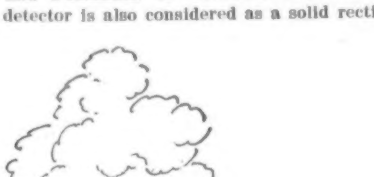


Fig. 15.

device. It is the actual energy of the faint high-frequency currents that is rectified and made to produce the click in the telephone receiver. This silicon detector may also be used in connection with a local circuit having a battery and telephone.

The carborundum detector is shown in Fig. 13. This may work without a battery in the local circuit, but

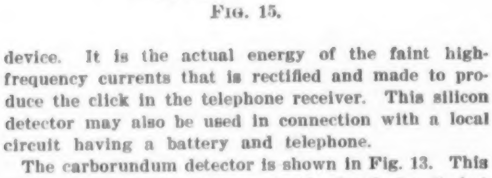


Fig. 16.

ordinarily a local battery is used. A carborundum crystal, *X*, is held resiliently against a conductor, *b*. The carborundum used is secured by selecting a suitable crystal from a mass of carborundum such as is made at Niagara Falls in the electric furnaces. By exercising sufficient care in the selection and mounting of the crystal an extremely sensitive self-restoring detector is produced.

Indeed, many crystalline substances serve for wireless telegraph detectors. Experimenters are finding out that very many crystalline substances have the property of responding to electrical waves to some degree or other.

In Fig. 14 is represented what the author believes to be one of the best and most sensitive detectors of the present day. This is also due to Mr. Pickard, and is known as the "Pericon" detector. It is self-restoring and requires no local battery, as in the case of the silicon detector. In engagement with a mass of fused zinc oxide, *Z*, is a metallic or other conductor, *A*. Zinc oxide is fused, preferably in an electric arc, and when cool a piece is fractured to produce a sharp edge or roughened surface for the engagement of the conductor, *A*, or the natural mineral may be used.

While different types of detectors have been shown, some connected in certain types of receiving circuits or arrangements, it must be understood that different detectors may be used in various different circuit arrangements and connections. A detector, in general, does not require any particular arrangement of circuits or mode of connection, but some modes of connection are more effective than others.

It may be interesting to know that the usual aerial conductor or antenna, with its necessary mast or other means of support, is not always required, though it is required for best operation. It has been found, as shown in Fig. 15, that a living tree may be used as a means for collecting high-frequency energy from the ether. A spike may be driven in the tree near the top and connected through the detector, *M*, to the earth, the usual local circuit with battery, *B*, and telephone, *T*, being provided. This arrangement, the author understands, works quite satisfactorily, especially for emergency work, and a tree may be used as a part of a transmitting apparatus.

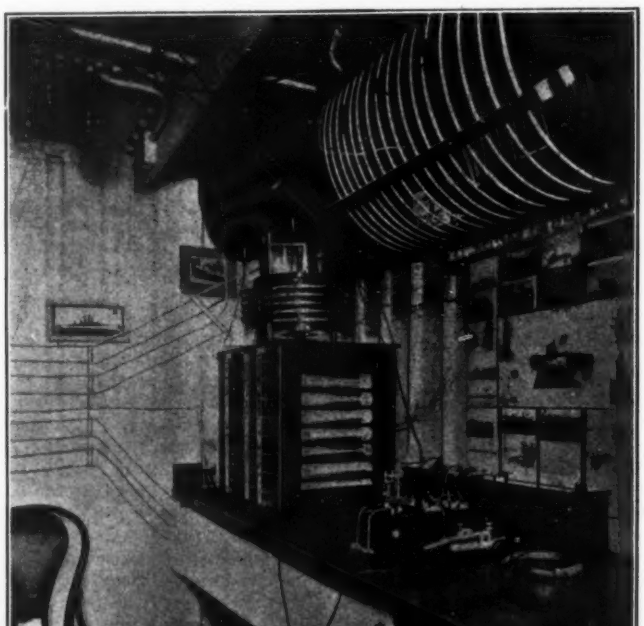


Fig. 17A.

In Fig. 16 is shown the aerial conductor arrangement of the United States ship "Topeka"; some of the wire cages, previously referred to, are insulated at the mast head and at other places, with leads to the operating room near the stern of the vessel. At the extreme top between the cages there is a small spark gap, which during the transmission of messages equalizes the potential on the two cages and their connecting wires.

Fig. 17 is a diagrammatic view of the circuit connections of a complete wireless telegraph receiving and transmitting outfit as installed on United States ship "Maryland." The direct-current motor is driven off the ship's circuit, an automatic starting box being provided. The motor drives an alternating-current generator at suitable speed to get the desired primary frequency. The energy from the alternator is used in

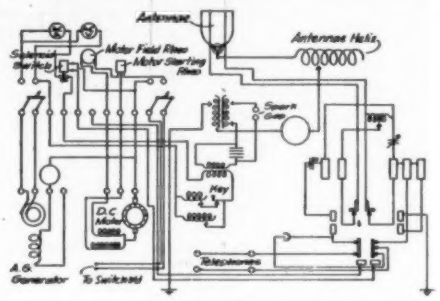


Fig. 17.

the primary of the step-up transformer, the secondary supplying a closed oscillation circuit, inductance, spark gap, and condenser. The antenna has an anchor spark gap at the bottom so that the two halves of the antenna may operate in common in transmitting and independently in receiving. These matters of ship and other installations have now reached an engineering stage and the different control parts, instruments, etc., are mounted on a switchboard.

Fig. 17a shows this same system as installed in the operating room of the United States ship "Maryland." On the table in the corner are recognized the Leyden jars forming the oscillation circuit condenser. On top of it is the helix forming the inductance of the oscillation circuit. With its axis horizontal and at the top of the room is shown the antenna helix for effective lengthening the antenna. On the small box on the table is shown the primary cell detector with switching apparatus, and upon the table is also seen the head telephone for the operator, comprising a watch case receiver for each ear, the two receivers being

* Proceedings of the Engineers' Club.

connected by a band for holding them upon the operator's head.

The antenna helix near the top of the operating room is like the one in Fig. 17. It is a coil of bare wire upon a suitable frame, and the same frame carries on one side a hot wire ammeter which measures the amount of current flowing up the antenna. It may seem strange that an open-ended wire, like an antenna, can receive a current; but such is the case, and

desired wave frequency or length within the range of the instrument.

The signal corps of the United States army has entered the wireless telegraph field and requires portable sets. The portable generator is driven by two opposed cranks, which are turned by several soldiers. This generator furnishes current for the induction coil or transformer of the transmitting outfit, which is located in a tent near by, the aerial conductor being

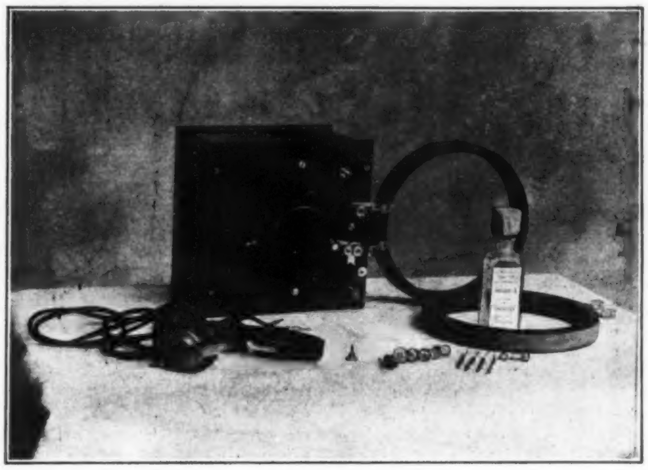


Fig. 18.

by a hot wire ammeter the amount is indicated. The ammeter is used not merely to satisfy curiosity as to the amount of energy going up the antenna, but is a means for knowing when the inductance in the aerial path and the inductance in the condenser circuit are properly correlated for maximum effect. When these inductances are properly correlated a maximum of energy will flow up the antenna.

With the rapid advance of this art, and with its reaching an engineering stage requiring the subject to be reduced to an exact science, there has sprung up a necessity for a frequency or wave meter for these high frequencies used.

Such a wave meter is shown in Fig. 18. Within the box is an adjustable condenser whose armatures comprise a series of stationary plates within which may interleave a series of movable plates, of course without contact, the dielectric being air. By rotating the movable plates by the handle, carrying a pointer, the amount of capacity is adjusted. In circuit with the condenser is an inductance, shown in the coil supported upon the end of the box.

Suppose you have a transmitting apparatus whose frequency or wave length you wish to determine. You hold this portable instrument within the range of influence of the transmitting apparatus, but without any connecting wires. You then adjust the condenser and move the pointer over the scale. A small detector, such as the primary cell detector above described, is connected across the terminals of the condenser or the inductance and in shunt with it is connected the telephone shown upon the table. When the needle is on that point of the scale corresponding with the loudest response in the telephone, and the point is sharply defined, you know that you have your wave meter in resonance or in tune with the transmitter whose frequency or wave length is to be measured. You can then read the wave length directly off of the scale, if it be calibrated in frequencies or wave lengths; or if it be calibrated merely in degrees, you can refer

— Wireless Telephony —

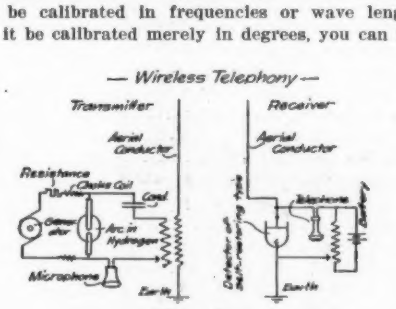


Fig. 19.

to a table belonging to the instrument, which will then immediately give you the wave length or frequency of the transmitter. Upon the table you will see four small glass tubes constituting spare platinum points of the primary cell detector.

This instrument may also be used as a standard for producing a wave of a definite frequency or wave length. To do this a small spark gap, whose terminals are mounted upon the box, is opened and the terminals connected to a very small induction coil. When sparks pass across the gap, the apparatus will produce waves of a frequency or length corresponding to the frequency or length of that point in the scale to which the pointer is directed. Thus, by moving the pointer to different positions you can produce any

held in the air by a portable jointed mast arrangement.

For wireless telephony any of the receiving arrangements and self-restoring detectors herein shown are suitable. The real problem in wireless telephony is in the transmitting apparatus, where it is necessary to secure either sustained oscillations, or wave trains or groups succeeding each other at a frequency above the limits of audition; and with either arrangement it is necessary to control the radiated energy by the human voice.

A wireless telephone system in which the oscillations are substantially continuous or sustained is

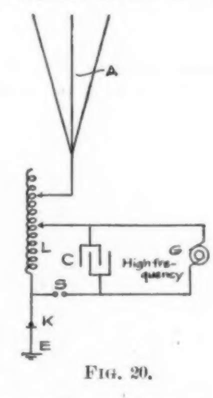


Fig. 20.

shown in Fig. 19. A generator supplies current through a non-inductive resistance and choke coils to the terminals of an arc which may be placed in an atmosphere of hydrogen. In shunt to the arc is a circuit including a condenser, a telephone microphone, and inductance, the latter being variable and serving as a primary of an oscillation transformer whose secondary is connected between the aerial conductor and earth. The capacity and inductance of the circuit including the arc and microphone is made such that high frequency oscillations result in the condenser circuit. These oscillations seem not to die out or dampen at all; one oscillation succeeds the other with substantially uniform amplitude, so that there is radiated from the aerial conductor into space a continuous stream of waves, not broken up into groups, as in the case of Fig. 4, for telegraphy. By talking to the microphone, the amplitude of the radiated waves may be varied, perhaps somewhat in frequency, but principally in amplitude. At the receiver these oscillations become high-frequency alternating currents of minute power in the aerial conductor and pass down to a detector of the self-restoring type. The detector, as the Pupin, Vreeland, or Fessenden detector, or silicon detector, or any other suitable self-restoring detector, causes the response in the detector to vary in accordance with the rising and falling in the quantity of the received energy, with the result that the current through the telephone varies in like manner and, consequently, reproduces speech.

But even though the oscillations produced by the transmitting apparatus are not strictly continuous or sustained, nevertheless they die out at a rate which is extremely small compared with the rate illustrated in Fig. 2. It may be that such a transmitter delivers overlapping trains of very slightly damped oscillations. In any event, such a transmitter and receiver suffices for wireless telephony.

Or the transmitter may be such that the sparks occur extremely rapidly; indeed, at a frequency above the limit of audition in the receiving telephone at the distant station. Indeed, a spark gap at a frequency of from five to ten thousand will probably in most cases suffice. Then the amplitude of the radiated energy may be controlled by a microphone, and at the receiving station the operation above described takes place, with the reproduction of speech. Because the energy is transmitted in wave trains which succeed each other at a rate above audition, the detector at

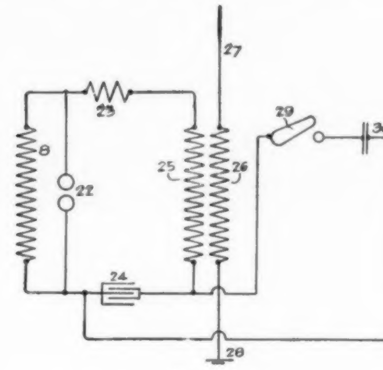


Fig. 21.

the receiving station responding at such high rate, there is no noise produced in the telephone. Only speech is reproduced in the telephone, owing to the rise and fall of the energy at a much slower rate, corresponding with the far lower frequencies characteristic of the human voice. Such a spark gap system is shown in Fig. 20, where the generator, *G*, is of sufficiently high frequency to produce wave trains or groups which shall be above the limit of audition in the receiving telephone. Here the microphone, *K*, is placed directly in the aerial near its base, and being in this position varies the amplitude of the radiated energy in accordance with speech.

Another method of wireless telephony is one in which the amplitude of the radiated energy is not varied in accordance with speech. On the contrary, the amplitude of the radiated energy remains substantially constant, but the *frequency* of the energy is varied in accordance with speech.

A transmitter for such purpose is shown in Fig. 21, where 8 is the secondary of a transformer delivering current at a frequency above the limit of audition to the circuit including the spark gap, 22, inductance, 23, the condenser, 24, and the primary, 25, of an oscillation transformer whose secondary, 26, is connected between the radiating conductor, 27, and earth, 28. The telephone transmitter in this case is the condenser, 30, which is connected when the switch, 29, is closed in parallel with the main condenser, 24. By talking against one of the armatures of the condenser, 30, the distance between the armature is varied, and, therefore, the dielectric between the armatures is varied, with a resultant variation of the capacity of the condenser, 30, in accordance with speech. This then varies the natural period of the circuit of the main condenser, 24, in accordance with speech, so that the radiated energy, while remaining substantially constant in amplitude, varies in frequency in accordance with the human voice. At the receiving station the self-restoring wave detector, such as the Pupin or silicon detectors, may be connected in any suitable way, such as in shunt to an inductance, and such that it shall be responsive to frequency changes and thus

Wireless Telephony
Frequency Variation

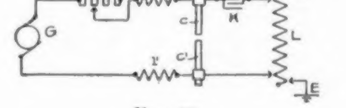


Fig. 22.

cause in the telephone the reproduction of speech.

In Fig. 22 the same frequency variation is shown in a transmitter involving an arc producing sustained oscillations instead of separated wave groups, as in the preceding figure. Here again speech uttered against the condenser, *K*, will vary the frequency of the transmitted energy by and in accordance with speech.

From Europe come reports that wireless telephony has been successful over distances of from 100 to 250 miles; and in this country, the author believes, several have been able to communicate over 100 miles. The arc system is generally used for such purpose, but there are inherent disadvantages in the arc system in getting sufficient energy into space. The arc system is quite suitable where relatively small amounts of energy are transmitted.

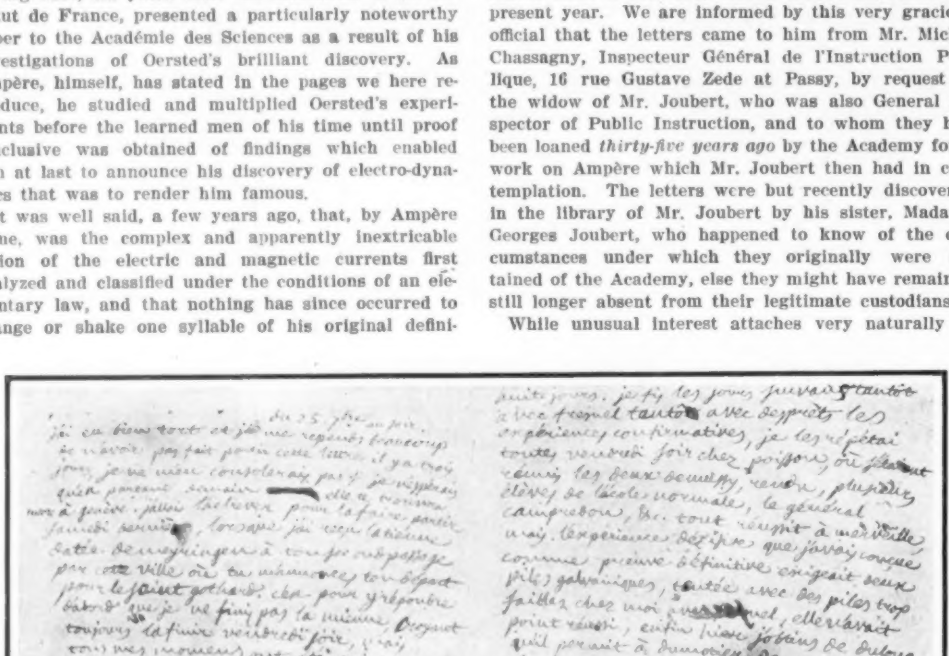
ANDRÉ MARIE AMPÈRE.

THE FOUNDER OF THE SCIENCE OF ELECTRO-DYNAMICS.

BY P. F. MOTTELAY.

As our readers already know, the name of Ampère has been given to the unit of intensity. It was so called after the great French natural philosopher, André Marie Ampère (1775-1836), who was the author of numerous very valuable contributions to the different scientific publications of his day, and who, during 1820, six years after his admission to the Institut de France, presented a particularly noteworthy paper to the Académie des Sciences as a result of his investigations of Oersted's brilliant discovery. As Ampère, himself, has stated in the pages we here reproduce, he studied and multiplied Oersted's experiments before the learned men of his time until proof conclusive was obtained of findings which enabled him at last to announce his discovery of electro-dynamics that was to render him famous.

It was well said, a few years ago, that, by Ampère alone, was the complex and apparently inextricable action of the electric and magnetic currents first analyzed and classified under the conditions of an elementary law, and that nothing has since occurred to change or shake one syllable of his original definitions. Through his very beautiful theory of molecular currents, he gave a theoretical explanation of the connection between electricity and magnetism which had been the dream of previous investigators. And, it can be truthfully stated that if we except the discovery of the laws of the induction of electric currents, made some ten years later by Faraday, no advance in the science of electricity can compare for brilliancy and completeness with the great work that Ampère accomplished.



REPRODUCTION OF TWO PAGES FROM RECENTLY DISCOVERED LETTER OF AMPÈRE ON HIS THEORY AND EXPERIMENTS IN RELATION TO THE MAGNET.

He always wrote extensively to many of his numerous friends about all his researches, which he was wont to detail in the most interesting manner, but to no one did he do so more genially and more acceptably than in the letters he frequently sent to his only child, the antiquarian-librarian, Jean Jacques Ampère (1800-1864), for whom his paternal affection was of the very greatest. This is evidenced throughout the two volumes of Ampère correspondence published in Paris during the year 1875. Among the letters therein will be found, more particularly, one from J. J. Ampère, dated Geneva, 23rd September, 1820, which acknowledges a letter of his father announcing the discovery of electro-dynamics (*felicitations filiates*); also one dated Paris, October 8th, 1826, from André Marie Ampère to his son, informing him that, as Mr. Herschell spoke to Mr. Wollaston of his researches and had expressed a desire to witness them, he would renew the experiments on the day following. In this last named letter he alludes to the forthcoming publication of his memoir on electro-dynamical phenomena. These volumes do not, however, contain the letters which are the object of the present article. They are three in number and were addressed by Ampère to his son under dates: Amiens, July 29th, 1820, four pages; Paris, August 6th, 1820, four pages; Paris, September 19th, 1820, one page, with the addition of three more pages within six days later, i. e., September 25th, 1820.

The three letters here alluded to were unexpectedly received not long since by Mr. Gaston Darboux, Sécrétaire Perpétual de l'Académie des Sciences, who presented them to that body on the first of August of the present year. We are informed by this very gracious official that the letters came to him from Mr. Michel Chassagny, Inspecteur Général de l'Instruction Publique, 16 rue Gustave Zede at Passy, by request of the widow of Mr. Joubert, who was also General Inspector of Public Instruction, and to whom they had been loaned *thirty-five years ago* by the Academy for a work on Ampère which Mr. Joubert then had in contemplation. The letters were but recently discovered in the library of Mr. Joubert by his sister, Madame Georges Joubert, who happened to know of the circumstances under which they originally were obtained of the Academy, else they might have remained still longer absent from their legitimate custodians.

While unusual interest attaches very naturally to everything written by the eminent scientist, we cannot give space to a reproduction, much less to a translation, of the numerous pages specified above. We think we will amply satisfy the curiosity of our readers if we give but two of the pages, which we have been allowed to photograph exclusively, and if we render, besides, the translation of these two pages written by Ampère under date of 25th September, 1820. The translation is as follows:

It was quite wrong of me, and I regret very much not having mailed this letter three days ago. I would not be content (*ne m'en consolerais pas*) were I not in hopes that, when leaving to-morrow, my letter will still find you in Geneva. I was about finishing it so as to have it go last Saturday when I received the letter you wrote from Meyringen, upon your second visit to that city, wherein you announce your intended departure for the St. Gothard. It is preferably to acknowledge your letter that I do not now continue my vi.w, hoping still to finish it on Friday evening; every moment of my time has been taken by what is to me an important life event. Since I first heard of the fine discovery by Mr. Oersted, professor at Copenhagen, of the action of galvanic currents upon the magnetic needle, I have continually given it thought. I have written much and have framed a great theory upon these phenomena, as well as upon all those previously known of the magnet, besides making experiments suggested by that theory which have all been successful and have acquainted me with many new results. I read the beginning of a memoir at Monday's sitting (of the Academy) eight days ago. During the subsequent days, sometimes with Fresnel[1] and sometimes with Despretz,[2] I made confirmatory experiments. On Friday, I repeated them all at the residence of Poisson,[3] where I had met the two De Mussey,[4] several students of the Normal School, General Campredon,[5] etc. Everything succeeded marvelously well, but the decisive experiment, which I had conceived as conveying proof conclusive, required two galvanic batteries. When I attempted this experiment at home in presence of Fresnel, it had not succeeded, for my battries were too weak. Yesterday, however, I obtained of Dulong[6] leave to buy of Dumotier the large battery constructed for the course of natural philosophy at the Faculty and which he had just finished. This morning the experiment was made at the home of Dumotier with great success and it was repeated, four o'clock to-day, at the sitting of the Institute. No more questions were raised, and now we have a new theory on the magnet which in reality shows that all its phenomena hold close relationship to those of Galvanism (or, identifying all its phenomena with those of Galvanism). This resembles in no wise (is totally unlike) all heretofore said of it. I will explain it anew to-morrow to Mr. de Humboldt[7] and after to-morrow to Mr. de la Place,[8] at the Bureau des Longitudes . . . . . Your father embraces you many thousand times. A. Ampère.

We do not think it necessary to detail here the numerous epoch-making papers which Ampère has brought to the notice of learned bodies, touching the above named as well as his other discoveries. They will all be found recorded in the encyclopædias, as well as in the special works which, at the time, his remarkable researches called for throughout the entire scientific world.

METALLURGY OF IRON.

Some new points relating to the metallurgy of iron and other metals have been brought out in France by M. G. Charpy. His experiments bear upon the rôle of carbon and carbon monoxide in metallurgical reactions. From careful tests he concludes that *in vacuo* and at 1,000 deg. C. (1,832 deg. F.), carbon in any of its forms does not combine with iron. Cementation is produced on the contrary by carbon monoxide. It follows from this that a trace of oxygen introduced with the iron-carbon systems permits the carbureting to take place. As to the action of carbon monoxide in excess upon the metals, it is difficult to study the reactions, since we need clearly to separate the action of carbon monoxide on the metal from the dissociation proper of this gas into carbonic acid gas and carbon. This dissociation is negligible at temperatures above 800 deg. C. (1,472 deg. F.) However, it is above this heat that the cementation of iron takes place. At lower heats, in spite of dissociation, he never observed any oxydizing action on the iron. The carbureting action was noticed up to about 600 degrees. Nickel acts like iron and is not oxydized, but the carbureting effect is about zero. With chromium and manganese carbon monoxide has a clearly oxydizing action, even at 1,000 deg. C. (1,832 deg. F.). There is formed sesquioxide of chromium and protoxide of manganese, with a deposit of carbon. In observing the action upon the oxides, we take account of the dissociation of the carbon monoxide by determining the carbonic acid gas and the carbon. From the weight of this latter we deduce the proportion of carbonic acid gas coming from the reduction. With sesquioxide of iron, be obtained a complete reduction below 300 deg. C. (572 deg. F.). Nickel oxide acts in the same way. The higher oxides of manganese are brought to the state of protoxide. Sesquioxide of chromium is not reduced. These experiments show some interesting points in the metallurgy of iron. It was admitted that solid carbon reduced sesquioxide of iron between 450 and 500 deg. C. (842 and 932 deg. F.). M. Charpy demonstrates that the reduction occurs at a lower temperature. It follows that in the blast furnace there occurs a reduction by carbon and carbon monoxide from 300 to 400 deg. C. (572 to 752 deg. F.) and that above this heat the reduced iron undergoes the carbureting action so as to give rise to divers states of equilibrium corresponding to the temperature of the process.

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[1] Fresnel (Augustin Jean) French physicist, 1788-1827.
[2] Despretz (César Mansuète) French physicist, 1789-1863.
[3] Poisson (Siméon Denis) French mathematician, 1781-1840.
[4] Mussy (François Guéneau de) French doctor, 1774-1857, and (Philibert Guéneau de) French author, 1776-1864.
[5] Campredon (Jacques D. M. de) French general, 1761-1837.
[6] Dulong (Pierre Louis) French chemist and physicist, 1785-1838.
[7] Humboldt (F. H. Alexander von) German naturalist, 1769-1859.
[8] La Place (Pierre Simon de) celebrated French geometer, president of the Bureau des Longitudes, 1749-1827.

THE PONS ASINORUM.—I.*

NEW SOLUTIONS OF THE PYTHAGOREAN THEOREM.

BY ARTHUR R. COLBURN, LL.M., OF THE DISTRICT OF COLUMBIA BAR.

THEOREM.—The square on the hypothenuse of a right triangle is equal to the sum of the squares on the other two sides.

Solution 1.—Let the triangle ABC be a right triangle with the right angle at B. Upon the hypothenuse AC erect the square $ADEC$, so as to include the triangle ABC. From the corner E draw EE' perpendicular to BC. From the corner D draw DD' perpendicular to EE'. From A draw AA' perpendicular to DD'. The lines AA' and AB coincide, being both perpendicular to BC from the same point, A; BC and DD' being parallel, since both are perpendicular to EE'. The angles at B, E', D' and A', are all right angles (by construction). The angle DAA' equals the

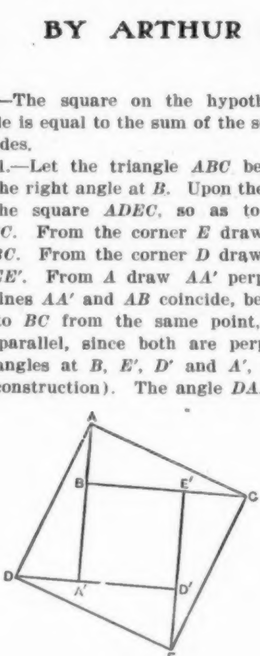


FIG. 1.

angle ACB, (being equal complements of the angle BAC). The angle ACB equals the angle EDD' (alternate included angles of intersecting parallels). So the angle CEE' equals the angle DAA'. Therefore, the triangles ABC, $CE'E$, $ED'D$, and $DA'A$ are all equal, similar right angle triangles (having, each, one side and corresponding angles equal). Therefore CE' equals AB equals DA' equals ED' (homologous sides of equal, similar triangles). Therefore, BE' equals $E'D'$ equals $D'A'$ equals $A'B$ (equal complements). And parallelogram BD' is a square. To prove $\overline{AB}^2$ plus $\overline{BC}^2$ equals $\overline{AC}^2$. The area of the four equal triangles equals $4\left(\frac{AB \times BC}{2}\right)$ equals $2\ (AB \times BC)$. The four triangles plus square BD' equals square AE. But square BD' equals $(BC—AB)^2$, since CE' equals AB (homologous sides of similar, equal triangles). And square AE equals $\overline{AC}^2$. Then $2\ (AB \times BC)$ plus $(BC—AB)^2$ equals $\overline{AC}^2$. $2\ (AB \times BC) + \overline{BC}^2 — 2\ (AB \times BC)$ plus $\overline{AB}^2$ equals $\overline{AC}^2$. Therefore $\overline{AB}^2$ plus $\overline{BC}^2$ equals $\overline{AC}^2$.

The square of the hypothenuse of a right triangle is equal to the sum of the squares of the other two sides.

Solution 2.—Given the right triangle ABC, to prove $\overline{AB}^2+\overline{BC}^2=\overline{AC}^2$. On the hypothenuse AC construct the square $ADEC$. On the short side AB complete the square $AHIB$. On the long side BC complete the square $BFGC$. Produce the line FG to intersect CE.

FG produced intersects CE at E; for triangle EGC=triangle ABC (being perpendicular thereto, and therefore similar; and having $GC=BC$ by construction; also the angles at G and B are right angles, and angle GCE=angle BCA (being equal complements of angle ACG to form a right angle).

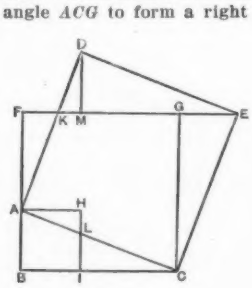


FIG. 2.

Let K be the intersection of FG and AD; and L the intersection of AC and HI.

Comparing triangles FAK and ICL: Angle FAK=angle ICL (being perpendicular), angles at F and I are right angles (by construction), $FA=IC$ (since $FB=BC$, and $AB=BI$). Therefore, triangle FAK=triangle ICL (being perpendicular, similar triangles, with equal homologous sides).

The polygon $CAFE$=square BG, (since triangle ABC=triangle EGC). Draw DM perpendicular to FE. Triangle DME=triangle ABC (being parallel, with equal hypothenuses).

* Copyright, 1910, by Arthur R. Colburn.

Triangle DMK=triangle AHL (being perpendicular right triangles, and DM $(=AB)$ $=AH$, and DK $=AL$, as it has been shown that $AK=CL$; and $AD=CA$ (by construction).

Therefore, triangle KDE=square $AHIB$ + triangle KFA.

Therefore, square AE = square $AHIB$ + square $BFGC$; or $\overline{AC}^2 = \overline{AB}^2 + \overline{BC}^2$.

Solution 3.—*Variation of Solution* 2.—This plan of proof may be varied as follows:

The diagram below may be constructed upon the triangle ABC in the same manner as above; whereupon the triangle ABC = triangle $C'GC$ = triangle

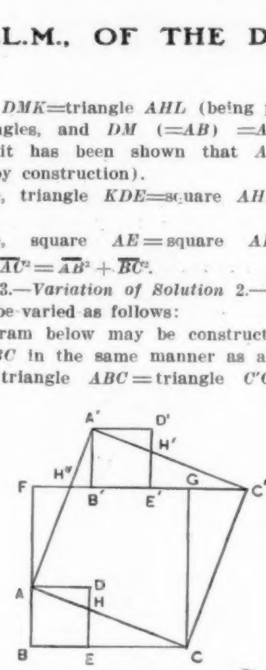


FIG. 3.

$A'B'C'$; triangle HEC=triangle $H'E'C'$=triangle $H''FA$; construct square $A'B'E'D'$, which will be equal to the square $ABED$; and triangle $A'B'H''$=triangle ADH.

The area of the small square upon AB, may be given place within the square on the hypothenuse by using the equivalent square $A'B'E'D'$, substituting triangle $A'B'H''$ for triangle $A'D'H'$.

The area of the square upon BC may then be given place within the square on the hypothenuse by substituting triangle $C'GC$ for triangle ABC; and triangle $H'E'C'$ for triangle $H''FA$.

This will occupy the whole area of the square on the hypothenuse.

To prove that the square on the hypothenuse of a right triangle is equal to the sum of the squares on the other two sides.

Solution 4.—Let triangle ABC be a right triangle, with a right angle at B. Complete the square on AC, marking the corners A' and A''. Produce BA

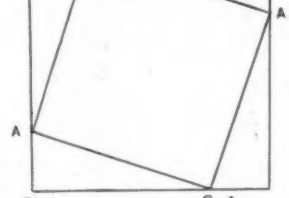


FIG. 4.

so as to intersect, as at B', a line perpendicular thereto from A'.

Triangle $A'B'A$=triangle ABC (being perpendicular thereto, and the hypothenuse of one equals the hypothenuse of the other).

$BB'=AB+BC$ (for $B'A=BC$). (In the same manner complete the triangles on the sides $A'A''$ and $A''C$; this will form a square upon the line BB', containing four similar equal right triangles, and the square on the hypothenuse, AC.)

To prove $\overline{AB}^2+\overline{BC}^2=\overline{AC}^2$.

$$\overline{BB'}^2 = 4\left(\frac{AB \times BC}{2}\right) + \overline{AC}^2.$$

Substitute $AB + BC$ for BB',

$\overline{AB}^2 + 2\ (AB \times BC) + \overline{BC}^2 = 2\ (AB \times BC) + \overline{AC}^2$.

$\overline{AB}^2 + \overline{BC}^2 = \overline{AC}^2$.

The square on the hypothenuse of a right triangle equals the sum of the squares on the other two sides.

Solution 5.—Given a right triangle, ABC, with the right angle at B; prove $\overline{AB}^2 + \overline{BC}^2 = \overline{AC}^2$.

Construct the square on the hypothenuse AC.

Draw the perpendicular from B to AC, as BB', and produce the same to the opposite side of the square, as at D.

Construct the square upon AB.

The parallelogram AD=square AB (since triangles constructed as EAC and BAC' are similar, equal triangles, having two sides and the included angle of one equal to the same of the other; and triangle $EAC=\frac{1}{2}$ square AB, having same base and same altitude; and the triangle $BAC'=\frac{1}{2}$ parallelogram AD, having the same base, AC', and the same altitude, AB').

Therefore, the square on the hypothenuse of a right triangle is equal to the sum of the squares on the other two sides.

For, in the right triangle $AB'B$, which is similar to triangle ABC, the square upon its hypothenuse AB is equal to the parallelogram AD, which is equal to the square of AB' plus the square of BB'.

Complete the square upon AB', as at B''.

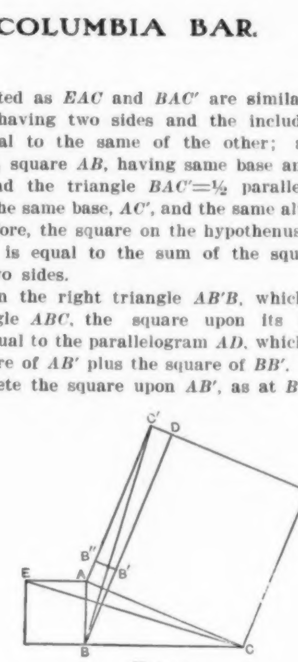


FIG. 5.

Then $B''C'=B'C$ (equals diminished by equals); and parallelogram AD=square AB' + parallelogram $B''D$.

And parallelogram $B''D=\overline{BB'}^2$ (or its equivalent, $AB' \times B'C=\overline{BB'}^2$; as BB' is a mean proportional between the two sections of the line AC into which BB' divides it).

To prove that the square on the hypothenuse of a right triangle is equal to the sum of the squares on the other two sides by the following plan of proof, namely: Add the two squares together in a parallelogram; erect a square equal to said parallelogram; then prove said square equal to the square of the hypothenuse.

Solution 6.—Let triangle ABC be a right triangle, with right angle at B. Erect the squares upon the three sides. To prove $\overline{AB}^2+\overline{BC}^2=\overline{AC}^2$.

Add the area of the square on AB to the square on BC. To do this, draw from some point, as D, in the line CB produced, the line DA perpendicular to AC; the triangle DAC will then be a right triangle; also AB will be a mean proportional between DB and BC.

Therefore $\overline{AB}^2=DB \times BC=DB \times BF$.

Therefore, parallelogram $CE=\overline{AB}^2+\overline{BC}^2$.

Construct a square equal to the parallelogram CE, by drawing a mean proportional between DC and DE, and compare same with the square on AC.

Produce CD to G, so that $DG=DE$.

Draw a semi-circumference on CG; at D draw the perpendicular to intersect said arc, as DH.

The line DH is the desired mean proportional between DC and DG $(=DE=BC)$, and represents a square equal to $\overline{AB}^2+\overline{BC}^2$.

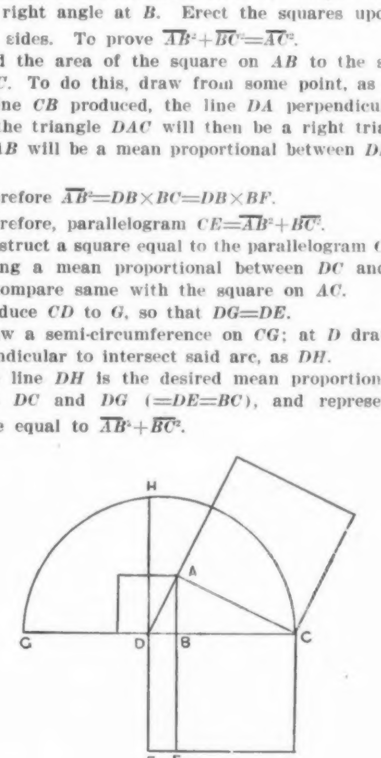


FIG. 6.

But AC is a mean proportional between DC and BC.

Therefore, $DH=AC$.

Therefore, the square on the hypothenuse is equal to the sum of the squares on the other two sides.

(To be continued.)

Dr. Felix Exner has been appointed to the chair of cosmical physics in the University of Innsbrück, left vacant by the appointment of Dr. Wilhelm Trabert to the directorship of the K. K. Zentralanstalt für Meteorologie at Vienna.

IN THE HEART OF AFRICA.—II.*

THE EXPEDITION OF THE AMERICAN MUSEUM OF NATURAL HISTORY.

BY MARY CYNTHIA DICKERSON.

Concluded from Supplement No. 1821, page 346.

THE expedition left Matadi by rail, reaching Leopoldville July 1st, beyond the cataracts and 320 miles from the coast. From there it proceeded by boat to Stanleyville, hoping to find this place suitable for a permanent base of operations. Stanleyville is 720 miles inland, twenty-two days' journey from Leopoldville, although the return trip requires only thirteen or fourteen days owing to the swiftness of the current. Most of the steamers on the Congo are stern-wheelers, of very shallow draught because there are so many sand bars. The expedition, however, did not utilize one of these steamers but took a barge, propelled by a twin-screw tug alongside. Wherever the boat stopped to take on firewood, the men went ashore, collected whatever was possible, and on coming back had the advantage of the large deck of the barge for work.

Of the voyage up stream Mr. Lang writes:

"The lack of any congregation of large birds must be a surprise to anyone, especially on such a mighty stream interrupted by so many forested or grass-covered islands. One kind of vulture is the most common large bird, but to see more than twenty in a day is unusual. There are some white-headed eagles. In Stanley Pool kites are common, sitting on the sand bars, in the neighborhood of which some solitary pelicans may be seen preening themselves or swimming. On shore there are ibis and geese. A few egrets emerge silently from the bushes on the swampy islands. Water turkeys, mostly single, but sometimes in pairs, disappear at once in the water or reeds, or very often take wing to establish another lookout on some branch farther off. To see a few large herons is an occasion, but it may become an exciting event if one discovers, on some distant sand bar, a few marabous. Small shore birds or pigeons may often enliven the edge of shores and sand banks; but the only large aggregations of any bird on the Congo during this season are composed of a species of Glareola, of which several large flocks have been observed. Even the birds that cross the river from time to time show no great variety; flocks of screaming gray parrots are common in the morning and evening, a few hornbills in very elegant swoop plantain eaters, single or in pairs, more seldom, duc heron and ibis. We distinguished five different ki of kingfishers as they darted out from the branches hovered over the water.

"On land it is quite different. Above Kwamouth, n only are larger birds more common, but indeed sm birds are fairly abundant, especially weaver birds, birds, bee eaters, wagtails, sandpipers, goatsuck

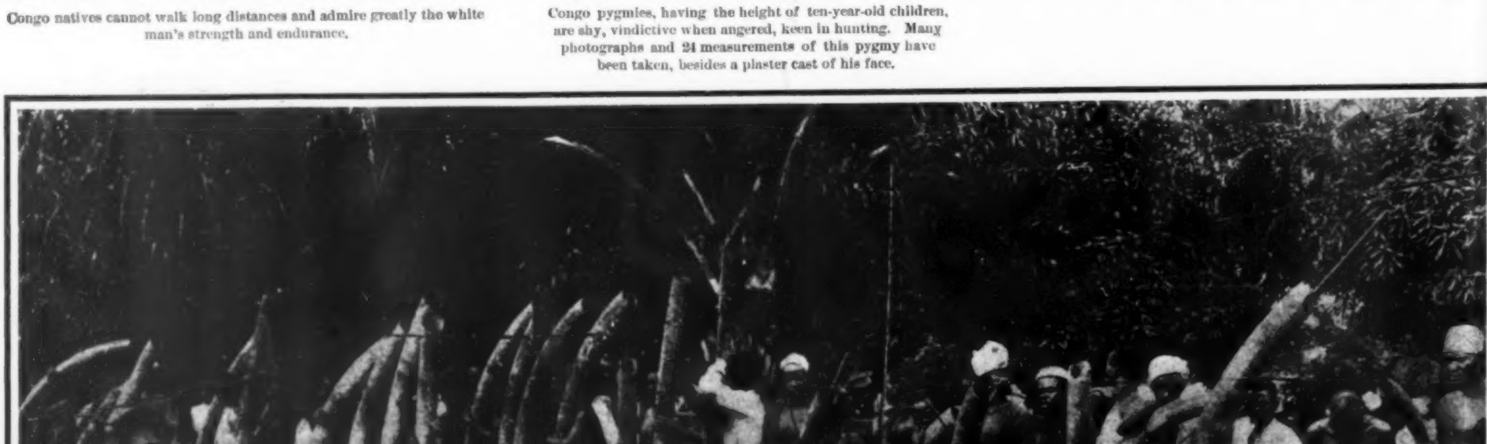
CONGO EXPEDITION ENTERING AVAKUBI STATION.

Congo natives cannot walk long distances and admire greatly the white man's strength and endurance.

MAMBUTI PYGMY, AVAKUBI.

Congo pygmies, having the height of ten-year-old children, are shy, vindictive when angered, keen in hunting. Many photographs and 24 measurements of this pygmy have been taken, besides a plaster cast of his face.

A RIVER BOAT ON THE WAY TO STANLEYVILLE.



IVORY CARAVAN.

A caravan with 97 tusks from the Haut Ituri. The largest weighs 106 pounds and is 9 feet long. Trade in the Congo is now in the hands of several nationalities.

IN THE HEART OF AFRICA.

* Reprinted from the American Museum Journal.

swifts, swallows, pigeons, rollers, and starlings. We were disappointed in our desire to see mammals from the boat on the journey up stream. There were occasional bands of monkeys sitting in trees near the shore, but no elephants trespassing or bathing in herds, and no buffaloes. In fact, the few places where elephants have been seen six or more years back are pointed out to you, like historic places. Even the hippos seem to resent the bullets that are invariably sent in their direction by the passengers of any passing boat. It is true that we saw some, but it took good looking and a strong field glass. If it happens that a young innocent hippo shows himself full size on a sand bar, the ever hungry negroes on board talk only of something to eat and proceed to shoot him."

Finding after all that Stanleyville was impossible as a base for operations, because of high prices and because too far distant from the most interesting zoological regions, decision was made to push on still farther east with a part of the supplies, to Avakubi in the Haut Ituri.

Certain bits of local color from Avakubi are in the following quotations from letters sent to friends and not intended for public reading:

"You laugh about the quinine, but I do not take quite ten grains a day. Every other day I take six grains and have become so accustomed to it that I do not notice any bad effects. Our medicine chest is quite a formidable affair, but seems to be mostly used for treating our black boys and porters, who are always having little illnesses, for which they want 'dawa' (medicine).

"Just now we are having the pleasure of inhabiting a house, built of bricks laid in mud, as they all are here, and roofed with palm leaves. . . . How you would laugh to see us catching bats in the evening with a butterfly net.

"Avakubi is a great rubber station, about twenty tons a month being received from the natives as taxes. Some elephant tusks are also received from the same source. There is a mission here with two priests who often shoot birds for us. They have added a number of good specimens to our collection. It has taken us an almost incredible time to get out to this place, and will take almost as long to get back. Such an isolated spot can hardly exist anywhere else in the world. A lieutenant who gets his newspapers by way of East Africa, and consequently much more quickly than if they came up the Congo, has lately informed us that Cook claims to have discovered the North Pole. This is about the only news from the rest of the world we have heard." (November 12th.)

That the place is isolated was well proved to the friends of the explorers when after August 14th, 1909, the months passed by and no word came. Anxiety increased, notwithstanding the knowledge that the expedition had gone far into the Haut Ituri district where it was difficult to get our mail. In late April, however, a sixty-six-page report dated November 29th, relieved all fear. They were putting in every hour from the first beam of light in the morning till nightfall, and often till midnight when the work required it, and that in a humid atmosphere of about 100 deg., but heroically said that all was so fascinating they were not thinking of discomfort. The report, which was rather bulky, had come by parcel post and had been nearly five months on the way.

The comparative isolation of the Congo is well illustrated in the matter of cablegrams. For instance, a cablegram from New York to a point five hundred miles inland in British East Africa will be answered in about eighteen hours, while one from New York to Boma or Matadi, only one hundred miles from the coast, will not even reach its destination for from ten to fifteen days. In fact, the delay is said to be sometimes so great that a letter may be received before the cablegram.

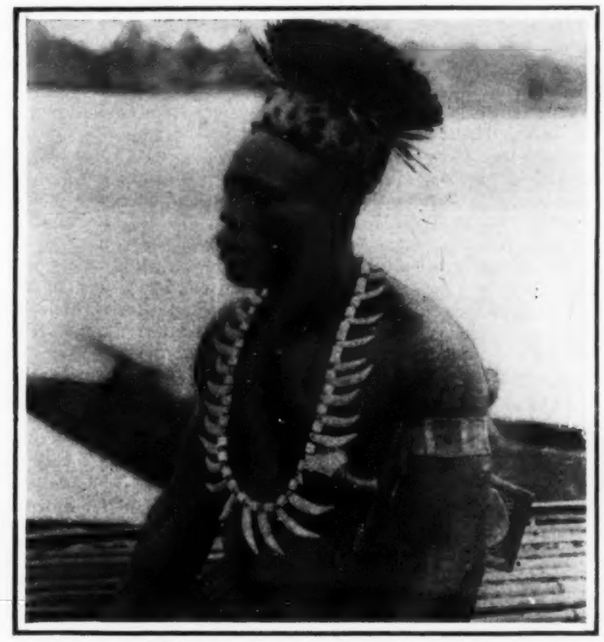
The report of November 29th shows remarkable industry. It reveals work astonishing in amount and careful and systematic to a degree. Mr. Lang is evidently living up to his reputation for speed and skill in the work of zoological survey and expert taxidermy; and not only this, but also such system is being used in labelling the material that the collection will have indubitable scientific value. It was the wish of the Museum that all specimens, large and small, should be individually tagged so that if at any time they had to be abandoned but did ultimately reach the Museum, there would be more chance of their scientific value having remained unimpaired. It scarcely seems possible that two men in the short space of two months after reaching their base of operations should have been able to prepare such a list of specimens, 291 mammals and 472 birds, besides more than 2,000 specimens of the smaller fauna. A later report sent out January 5th, little more than three months after reaching Avakubi, shows a record of 510 mammals and 762 birds, with more than 4,000 of the smaller fauna, and this collection covered by 400 pages of descriptive matter.

That so much has been done is due not only to speed and skill, but also to the foresight of the leaders in planning and to that force of personality which can get enthusiastic work from subordinates. Three assistants (Loangos, a tribe from the French Congo, known as very intelligent) were hired before leaving Leopoldville. These fellows were taught during the voyage up the river. Afterward, just before leaving Stanleyville, the last place where natives can be engaged by contract, fifteen assistants were hired—for a monthly payment of three dollars in addition to food.

"We have done our utmost (writes Mr. Lang) in training these natives and look forward with great pleasure to the results. Six of them can prepare small mammals, four can prepare birds, several of them can do the work on larger mammals, though all of them can take active part in it. Besides, two are successful hunters, and all know how to set traps for small mammals and to catch reptiles and batrachians. Several

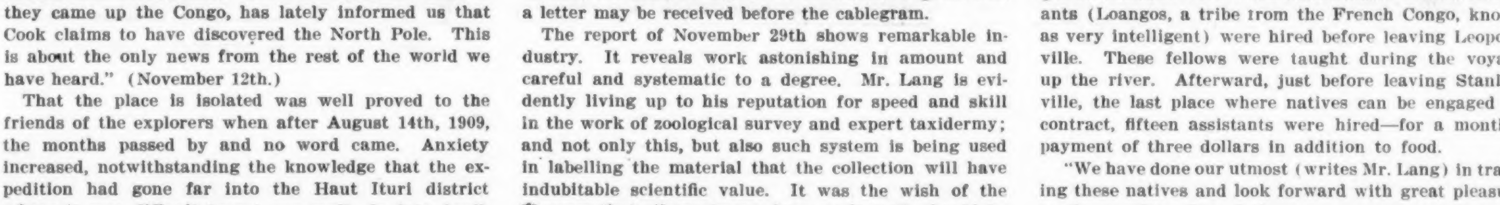
"TELEGRAPH" OPERATOR.

Sounds produced by beating at different points on the tom-tom are combined into a syllabic alphabet, so that any message, however complicated, can be sent.



CHIEF OF A RENOWNED CANNIBAL TRIBE.

The cap of leopard skin and red parrot feathers gives him wisdom; the chain of leopard canines confers the leopard's stealth and cunning. Instead of the ivory disk usually gracing the upper lip of the Congo native, he wears a polished leopard incisor.



HOW THE NATIVES FISH.

Arrangements have been made with the natives so that the expedition, on its return, will camp at the famous fisheries at Stanleyville till adequate fish collections can be made.

IN THE HEART OF AFRICA.

are very keen in catching invertebrates, and one is remarkable for finding different species of ants. Others are fishermen; they know how to weave native fish traps and they handle canoes with skill. As a whole they are a remarkable lot of natives, and I sincerely hope that the results will show what can be achieved by native assistance."

In addition to these trained assistants the expedition has forty porters for the work of ordinary occasions. The porters are not hired for a long period but are paid and discharged at the end of every trip, fresh ones being engaged in each new locality through the assistance of government officials. The porters of the Upper Congo cannot carry as heavy loads as those of British East Africa; fifty-five pounds (English) is taken as a maximum load. This results not only from their inferior physical constitution, for there are many strong and well-built porters, but it is, of course, more weakening, even for natives, to carry loads in the hot moist atmosphere of the forest than on the generally healthy plains of British East Africa. A very large caravan was necessary for the travel through the dense forest from Stanleyville to Avakubi; one hundred and sixty porters were hired at Stanleyville, and to get along quickly and safely twenty more were engaged from village to village. It is interesting to know that after twenty-two days' march under all the difficulties of making way through a wet tropical forest, this large caravan was brought to a safe arrival at Avakubi, having lost neither man nor load and with everything of the equipment in perfect condition.

To read the following quoted from Stanley's description of the Congo jungle brings a fuller appreciation of this march:

"Lean but your hand on a tree, measure but your length on the ground, seat yourself on a fallen branch, and you will then understand that venom and activity breathe around you. Open your notebook, the page attracts a dozen butterflies, a honey-bee hovers over your hand; other forms of bees dash for your eyes; a wasp buzzes in your ear, a huge hornet menaces your face, an army of ants come marching to your feet. Some are already crawling up, and will presently be digging their scissor-like mandibles into your neck. . . Imagine the whole of France and the Iberian peninsula closely packed with trees whose crowns of foliage interlace and prevent any view of sky and sun. . . . Then from tree to tree run cables from two inches to fifteen inches in diameter, up and down in loops and festoons and W's and badly-formed M's; fold them round the trees in great tight coils, until they have run up the entire height, like endless anacondas; let them flower and leaf luxuriantly, and mix up above with the foliage of the trees to hide the sun, then from the highest branches let fall the ends of the cables reaching near to the ground by hundreds. . . . Work others through and through these as confusedly as possible . . . on every horizontal branch plant cabbage-like lichens of the largest kind, and broad spear-leaved plants . . . and orchids and . . . a drapery of delicate ferns. Now cover tree, branch, twig, and creeper with a thick moss like a green fur. . . . To complete the mental picture of this ruthless forest, the ground should be strewn thickly with half formed humus of rotting twigs, leaves, branches; every few yards there should be a prostrate giant . . . half veiled with masses of vines . . . and every mile or so there should be muddy streams, stagnant creeks, and shallow pools, green with duckweed, leaves of lotus and lilies, and a greasy green scum. . . ."

In addition to the government assistance in the matter of porters, which has been due largely to the personal influence of Mr. Jules Renkin, Minister of Colonies, courtesies have been extended to the expedition in two other directions. It has been granted storage free of charge in every magazine of the Province Orientale, and has been allowed to get goods from the government storehouses. This latter privilege is of unusual importance as no money of any kind is used among the natives of the Upper Congo and the various kinds of articles, brass rods and accordeons, for instance, prized and accepted in trade among these tribes are so unusual in a white man's eyes that no adequate preparation could be made.

When the report of January 5th was sent, the active work on heavy game had not commenced. The expedition was on the point of engaging experienced native hunters and the very keenest pygmies to be found. It was in the district of large game where the trumpeting of elephants could be heard from the camp, and elephants' trails—deep round footprints "as if someone for amusement had gone about sinking a bucket into the mud and pulling it out again"—were common along the river and in the banana plantations. For the most part heavy game in Central Africa is protected by law and is relatively abundant, not near extinction as in South Africa.

The square-mouthed or so-called white rhinocerous, however, is not common anywhere in Africa. It is practically extinct in South Africa, is rare in the narrow strip of country west of the Nile—the Lado of Central Africa—and is wholly unknown in all other parts of the continent. The square-mouthed rhinoceros is on the average larger than the common African rhinoceros, has a double hump in the region of the neck and a head that differs wholly in shape from that of the common form, one striking point of difference being a square upper lip instead of a pointed overhanging one.

Also, the expedition was in the land of the okapi, with the hope of getting specimens for a group in the Museum. Less than ten years ago the world was stirred by the discovery of a new animal in the northern part of the Congo forest, *okapi*, the natives called it. Stanley had gained from the dwarfs some hint of it. He thought it related to the horse, in spite of the anomaly of a grass-eating animal living in forests. When actually seen, the okapi was found very wonderful: a shy animal, standing as high as a stag, and feeding on the leaves and twigs of trees, its sleek, glossy coat even brown above while zebra-like on the legs and posterior part of the body. Its foot has two hoofs but no vestige of the two small false hoofs characteristic of the deer. In fact, the okapi proves itself closely allied to a fossil animal, *Helladotherium*, of Greece and Asia Minor, its nearest living relative being the giraffe.

The hunting trips for large game will facilitate the work along anthropological lines since pygmies will be a part of the company. Besides, villages will be visited, having two or three hundred pygmies attached to them. Some successful casts have already been made of the faces of three pygmies, but dwarfs are so shy that they are reluctant to submit to the procedure. They were won over by having their hands cast first. After they had seen how simple a matter it is, they were induced to allow the plaster to be put on their faces.

A letter sent to friends in early January tells of the personal welfare and good cheer of the explorers:

"On Christmas we dined especially well and on New Year's day opened a canned plum pudding (!) that had been given to us in Stanleyville. Good food is not at all scarce here. Yesterday we looked over our stock and found we had seven live chickens, ten pineapples, three large bunches of bananas and various fresh vegetables and fruits. Sweet potatoes, whiter and not so tasty as those at home, grow like weeds on all sides. In fact, we scarcely need to draw upon our European provisions at all except for butter and sugar.

"From the first of December till two days after Christmas we stayed at N'Gayu, three days to the north of Avakubi, collecting mammals and other specimens which have been sent back to Avakubi. Our Christmas present was an old male chimpanzee captured on Christmas Eve."

A final word just received from the expedition, started June 30th from the Congo camp at Medje, north of Avakubi. With the introductory words, "There is only good news to be reported, all is well," there follows a triumphant record: 1,200 mammals and 1,500 birds are in the collections; a unique ethnological collection of 700 numbers has been gained from the Mangbetu; best of all, the okapi group is assured, not only in the possession of male and female specimens and young, but also, in that materials from the animal's haunt have been preserved and crated ready to ship, so that there promises to be reproduced in the near future in the American Museum of Natural History, New York, a small part of the mighty Congo forest with its strange life.

THE CANALS OF MARS.

By OTTO HOFFMANN.

THE opposition of Mars, which occurred last year and which, it was hoped, would furnish answers to numerous open questions, has brought little but disappointment. In particular, the problem of the so-called canals appears farther from solution than ever. The fame of Schiaparelli, the recently deceased pioneer in Martian topography, is enhanced by the certainty that his famous *canali* really represent something, but the observers are not in agreement as to what they represent. The majority of European observers regard the geometrical network of canals as an optical illusion, and those canals that have an unquestionable objective existence as formations of unknown structure, and fine detail, which the eye physiologically blends into lines. In this matter no help is given by the best photographs, as a series of points very near together appears as a line on the photographic plate. The most eminent European observers of the recent opposition, including Antoniadi, Jarry-Desloges, Fournier and de Jonckheere in France, Phillips in England, and Sola in Spain, have not yet given any opinion in explanation of the observed phenomena. On the other hand, Lowell and his associates still adhere to the theory, based upon many years of continuous observation under the clear sky of Arizona, that the markings are fine, regular, straight lines, which form a carefully planned network and represent canals constructed for the purpose of supplying water to the inhabitants of the almost dried-out planet. Prof. Lowell does not hesitate to assume that Mars is inhabited by intelligent creatures who, however, must differ greatly from earthly human beings in consequence of the difference in the conditions of life. Lowell even goes so far as to assert that four canals, which he recently discovered, are new artificial waterways, recently constructed by Martian engineers. If these canals had already been in existence, Prof. Lowell argues, they would certainly have been discovered at the Flagstaff observatory in the course of fifteen years of observation. Lowell's discoveries, which could not be verified with the aid of the largest telescopes in the world, have often been called illusions, and they were first so designated by Americans, but in the lectures which Prof. Lowell delivered in London, Paris, and Berlin, a few months ago, he presented his views so convincingly that many of his most violent opponents began to doubt. Several observers of Mars have expressed the opinion that telescopes of moderate size are preferable to very large instruments for the purpose of detecting the fine lines of the canals. Furthermore, Lowell's numerous photographs of Jupiter and Saturn demonstrate the remarkable excellence of the work done at the Flagstaff observatory. Prof. Lowell admits that the finest canals can be discerned only in very favorable atmospheric conditions, and for this reason Dr. Aitken has suggested that Lowell's most prominent opponents, including Pickering, Antoniadi, and Barnard, observe the opposition of Mars in 1911 with Lowell at Flagstaff. It does not appear probable that this suggestion will be followed. Prof. Svante Arrhenius, whose earlier writings contain much in regard to the riddle of Mars, has been led by his recent investigations to a novel and highly original theory, directly opposed to that of Lowell. Starting from the assumption that the temperature of Mars is too low to support life of any kind, Arrhenius concludes that the dark spots and bands do not represent areas covered by vegetation, and that the so-called canals, as Penard asserted long ago, are long and deep fissures formed by local sinking of the crust while the planet was still incandescent. Similar formations exist on the earth. The longest extends 2,200 miles along the coasts of Peru and Chile, and is therefore about as long as the Martian canal "Phison." The annual vanishing and reappearance of the canals are explained by Arrhenius as follows: The canals, or fissures, contain water, which is accumulated especially about the points where several canals meet. These areas, the "lakes" of Schiaparelli and the "oases" of Lowell, represent the places where the crust has fallen in. The water is very salt, like the water of desert lakes on the earth, but it is nevertheless frozen by the intense cold of the Martian winter. The ice evaporates, owing to the dryness of the air, and the resulting water vapor condenses as snow about the pole of the winter hemisphere. At the end of the winter season, therefore, the lakes and canals of one hemisphere have lost all of their water and contain only dry salts of various kinds. In spring and summer the polar snow gradually melts, the air becomes less dry, and the salts attract moisture from the atmosphere, causing the color of the canals to become darker.

This theory, however, is open to several objections. The presence of air and water on Mars is now admitted by all observers, including those who do not accept the spectroscopic evidence. If the mean temperature of Mars were really —22 deg. F., the poles should be always covered with snow, but the polar caps entirely vanish in summer and the formation of the dark bands indicates the presence of large quantities of water. The theory of Arrhenius also fails to account satisfactorily for the seasonal variations in the color of the dark spots and for the total disappearance of the canals in winter. If the canals were fissures in the planet's crust they should be visible on the red background of the continental areas, even in winter.

The observations of the recent opposition have not yet been fully published. Their publication will probably explain a few disputed points.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

At Sheffield, before the British Association for the Advancement of Science, Mr. A. D. Hall dealt with the causes of soil fertility, arriving, after a long history of past experiments, at the conclusion that evidently there was no simple solution to the question: What is the cause of the fertility of the soil? There is no single factor to which they can point as the cause; instead they have indicated a number of factors any one of which may at a given time become a limiting factor and determine the growth of the plant. All that science can do as yet is to ascertain the existence of these factors one by one, and bring them successively under control; but, though they have been able to increase production in various directions, they are still far from being able to disentangle all the interacting forces whose resultant is represented by the crop.

COLOR SENSITIVENESS IN ANIMALS.

THE RESULTS OF RECENT INVESTIGATIONS.

BY DR. ADOLF KOELSCH.

Whether animals see colors as we do, and at what stage of life first appears their capability of distinguishing them, are questions which found investigators as far back as 1850, but we find no progress in their solution until psychology entered the field of the experimental sciences about the end of the nineteenth century.

Since then from learned journals I have collected for discussion some very notable facts in this line.

Let us first consider those creatures which possess special organs—eyes, namely—for the reception of impressions of light and color.

The lowest forms of these are crabs and insects; if we pass by those few still lower, such as worms, sea-nettles, etc., which possess eye-like patches of pigment or eye-sockets.

The first recorded experiments are those of Sir John Lubbock, made with the well-known tiny fresh-water crab, belonging to the Daphnidæ, and sometimes called the water-flea, which covers the surfaces of our ponds in the summer by the thousand.

Like mussels, they are inclosed in a glassy, transparent shell, from which projects only the thick head with its big, four-cornered eyes and the long, thickly fringed oar-shaped antennæ.

This little animal has shown itself uncommonly sensitive to color, as a simple experiment easily proves.

Take a wooden trough, fill it with water, and project a solar-spectrum upon it from above so that it is covered with a continuous band of the colors lying between ultra-red and ultra-violet. Movable glass partitions are inserted corresponding to each color-zone. Before the spectrum is thrown upon the water, place within the trough a definite number, say, a hundred, of the crabs. Let the spectrum remain for ten minutes and then lower the glass partitions.

The ultra-red, the violet, and the ultra-violet chambers will be found completely empty. About three-fifths of the crabs will have gone into the green chamber and a fifth into the yellow, while the rest are divided between the red and the blue, with a larger percentage in the former. Complete darkness is more disliked even than blue, violet, and ultra-violet, for when compelled to choose between blackness and ultra-violet, 97 per cent choose the latter. Thus they seem to perceive as a degree of light, the ultra-violet invisible to our eyes.

The same is true of ants. They seem to fear nothing so much as exposing their larvæ (Puppen) to the light.

If a number of ants and larvæ be put into a box, half of which is covered with clear glass and the other half with a black cloth, the former hasten to carry the latter into the dark side. If the black cover be replaced by red glass the insects contentedly allow their charges to remain beneath it.

But if it be changed for another color, the ants show the greatest excitement and hastily remove their nurslings to the dark side. They seem to find blue extremely irritating, violet still more so, and worst of all the ultra-violet, imperceptible to human eyes.

Bees and bumble-bees also, according to Lubbock, Forel, Bert, Wery, and others, distinguished readily the basic colors of the spectrum, but show no preferences and are not disturbed by ultra-violet. Wasps, on the other hand, show little reaction to color, but take special notice of outline and have an excellent memory of form.

Little is known so far of color-sense in fish, though it is not entirely lacking. Miss Wasburn found in certain experiments with a fish, that after training by feeding, it chose the red object used forty-two out of forty-four times.

We are better informed as to the common water-newt or triton of our ponds. Like the water-fleas they find blue and violet light very disagreeable, choosing even the brightest red and yellow in preference, while they have a horror of the ultra-violet. While they hate the clear daylight, when they are forced to choose between that and ultra-violet, they crowd hastily into the white light.

This aversion to blue and to violet is peculiarly remarkable since these colors are marked features of the decorative mating-garb of the male. This is so contrary to what would be expected under the circumstances that it evidently involves an unsolved enigma. Similar phenomena are shown by the grass-frog, except that it is more indifferent to colors than its cousin, the newt. It decidedly prefers red to green, but seems scarcely able to distinguish between red and blue.

Still more interesting are the experiments made very recently by Karl Hesz, professor of ophthalmology at Wuerzburg, on the color-sense of chickens, pigeons, owls, and kestrels.

Hungry fowls and pigeons, accustomed to human society, were placed in a room whose amount of light could be graded and regulated at pleasure. The room was made very bright and the eyes of men and animals were allowed to accustom themselves to the light for an hour. Then a smooth, black cloth was placed on the floor, evenly covered with grains of wheat, and a strong spectrum thrown upon it from the ceiling.

When the hungry fowls were freed the following observations were made: All the chickens began to pick at the red end of the spectrum. They went first to the bright red, then to the ultra-red, afterward to the yellow, and finally to the green. A few kernels were picked from the blue-green, but they went no farther, though their hunger was quite unappeased. Why not? Simply because to them the blue and violet grains lay completely in darkness. They could not see them. On the other hand, they saw clearly the grains in the ultra-red, which were invisible to the men.

For chickens and pigeons, therefore, the spectrum is shortened at the violet end of short wave length and extended at the red end of long wave length.

"They stand in the same relation to the field of color," says Hesz, "as do men when wearing yellowish-red glasses."

In fact, as Hesz has demonstrated, these fowls wear such spectacles, not as artificial and exterior adjuncts to the eye, but imbedded in the light-sensitive iris. Here are found yellow and orange oil-globules in such enormous quantities that certain areas of the iris are dominated by them.

The experiment demonstrated that these oil-globules allow only the red, yellow, green, and blue-green rays of white daylight to pass. Blue and violet are completely shut off.

When Hesz donned orange-colored glasses he saw the grains just as the fowls did—those in the red and the red-yellow zones the best, the green less well, the dark blue and the violet in general, not at all.

For kestrels and buzzards the brightest zone was not red, but green, and invisibility began for them only at the end of the blue zone. Owls saw the colors just as do men.

These results seem to me very well worth noting in various respects. For if blue and violet simply look black to hens and to pigeons, then the splendid sheen and glitter of violet on the neck of the male pigeon or on the neck, the tail, and the wings of the rooster cannot possibly have the same beauty-value for these animals as for us. They do not even see these feathers as violet or blue.

It seems, therefore, very doubtful to regard these colors as a means of decoration, and to hold with Darwin that these feathers assist the male in the matrimonial market, giving the handsomest male the best chance of success. These colors appear to the female simply as black. It is, therefore, quite useless for a black cock to have magnificent purple-black tail feathers and a gleaming bluish circlet about the neck. To the female he appears merely a simple blackamoor!

Among the mammals the color-sense of dogs has been carefully studied.

Nagel and Himstedt, from whom I quote, made use of a "drill-method" of study. For example, they placed in front of a poodle a certain number of gray, green, and blue balls, with one of bright red. All the balls were of like size and scent.

The dog was commanded, "Bring red," and the red ball pointed out to him. The lesson was repeated until the command brought the red ball unerringly. Then the balls were increased by four others of like size, but tinted in all shades of red from the brightest to the darkest, namely, strawberry, carmine, orange-red, and finally, one of bismarck-brown with a slight dash of red.

When the poodle was now commanded to "Bring red," he brought first the fire-red ball to which practice had accustomed him. When the command was repeated he brought in order the strawberry-red, then the carmine, and after some hesitation the orange-colored ball. At further sharp orders he brought the brown ball after much consideration. When the command was again reiterated the dog showed much embarrassment, but still ignored the gray, the green, and the blue balls, showing thus that he distinguished all shades of red from gray, green, and blue.

Recently, two Russians have shown by another method of training that the dog is able to distinguish the most various shades of gray and of green.

According to Kinnaman and Yerkes an equally well-defined color-sense is shown by mice, cats, and apes, with a distinct preference for the one or the other color.

It has also been established that even animals without special organs for the reception of light are markedly sensitive to color-stimulus. The first convincing experiments in this line have been made by Graber. He placed earthworms in a box whose bottom was covered with earth. It was divided into two compartments by a partition extending not quite to the bottom. These compartments were covered respectively with red glass and with blue. Numerous experiments produced the same result. Four-fifths of the worms sought the red half of the box and therefore shunned the blue. Also the ultra-violet was as repugnant to them as to the ants and the salamanders. In spite of their strong aversion to daylight they always sought the white light in preference to the ultra-violet. They were able to distinguish green from red and yellow, and yellow from blue, and they showed plainly that the nearer a color was to the red end of the spectrum the more agreeable it was to them.

Since then eyeless creatures from all departments of the animal kingdom have been tested for color-sensitiveness, from one-celled protozoa to blind cave-dwelling vertebrates.

While a general law cannot be laid down, it has been found that nearly all "light-shy" creatures behave like the earthworms, while those eyeless animals on the other hand, which love light, show a marked preference for blue and for violet.

Others again, including particularly the deep-sea forms, prefer the chemically active ultra-violet zone to all other forms of light.

Naturally the term "color-perception" cannot be applied in the optical sense to all these cases. Color-sensation is a better expression, and we must imagine that color produces upon their skin sensations analogous to the sensations of warmth and coldness perceived by our own skin. Obviously, too, such sensations produce pleasurable or disagreeable impressions of varying intensity and thus enlighten the animal as to the nature of its surroundings and stimulate it to flee from the disagreeable or the dangerous.—Translated for the Scientific American from Die Woche.

PYRIDINE.

The industrial preparation of pyridine was treated not long since by Prof. C. Berger of the Paris University. This product, which has a penetrating odor, was discovered by Anderson in 1846 in animal oil coming from bone distillation. It had no application in practice for a long time except for medicinal purposes, but within late years it has found various uses which make it an industrial product of some value. Owing to its strong and very disagreeable odor it was chosen in Germany and England for denaturizing alcohol. More recently, pyridine has been used in the coal-tar dye industry for purifying anthracene. This last body, which is the basic material for the production of alizarine, requires to be freed from fluorene, pyrene and other bodies. Washing with benzine is less effective, as we obtain anthracene only 50 per cent pure, but treatment with pyridine gives an 82 per cent product. The purification is then completed by sublimation in steam. At present, pyridine is extracted from light tar oils by washing with sulphuric acid, which combines with pyridine as a base, and the product is saturated with ammonia. This is carried out by half-saturating in the first place in order to separate the phenols, when these latter are removed and the final saturating is carried out in tanks so that the pyridine separates and floats on the top, being decanted off, and water is removed by treating with caustic soda, finally rectifying by distillation between 110 and 125 deg. C. (230 and 257 deg. F.). The residue is formed by phenolic compounds. Commercial pyridine of the first class is colorless and does not contain more than 10 per cent of water, while the pure product boils at 115 deg. C. (239 deg. F.) and has a density of 0.985 at 15 deg. C. (59 deg. F.). It is of interest from the fact that it will combine with a great number of bodies so as to form many products. Owing to its recent production on a large scale, there will no doubt be found other properties for it.

THE WILLOWS DIRIGIBLE AIRSHIP.

ITS FLIGHT TO FRANCE.

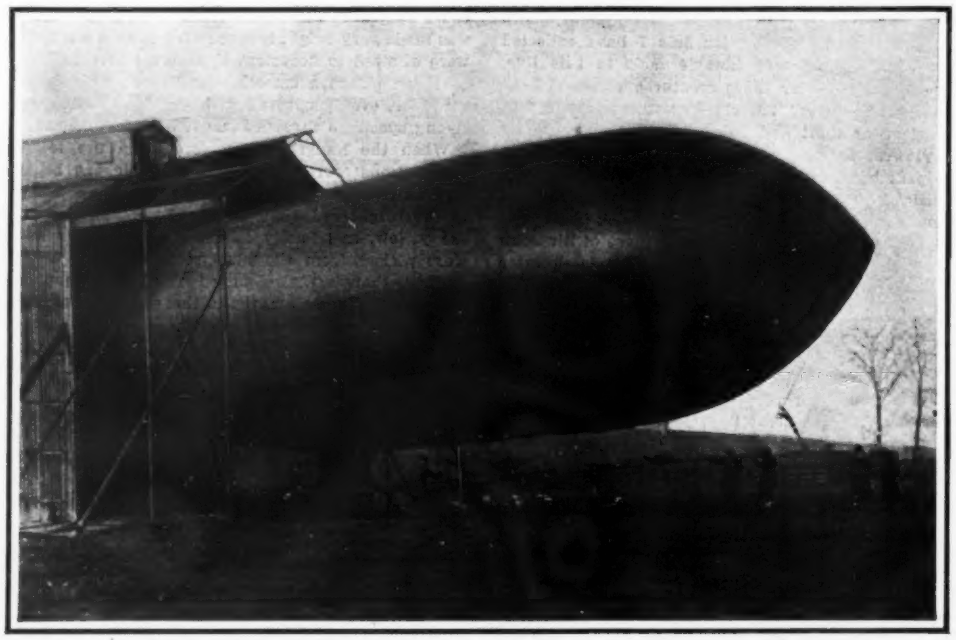
BY THE LONDON CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

Considerable interest has been created in English and continental aviation circles in the achievement of the young Welsh aeronaut, Mr. E. T. Willows of Cardiff, who navigated his craft from London to Douai, involving the crossing of the English Channel. Paris was his actual destination, but the navigator lost his bearings in the fog and darkness, so that when he descended he was ignorant of the place where he alighted, though cognizant of the fact that it was in France, and calculation showed that he had made a journey inland of 160 miles. The most important feature of the enterprise, however, is the fact that the channel was crossed during the night, the aeronaut steering by the aid of the stars, and it is the precision with which he picked out his course when landmarks were obscured by fog that has aroused the greatest interest. But for the fact that his mechanician accidentally dropped the Admiralty and other charts with which he was equipped, there is no doubt that he would have reached Paris. The French country, however, was strange to him, and though he endeavored to pick up his course, his efforts were in vain.

Willows left his hangar at Wormwood Scrubs, West London, at 3:25 Friday afternoon, November 4th, in his vessel, "The City of Cardiff." He first made for Trafalgar Square, circled the Nelson monument at an altitude of about 2,000 feet, and then set off for the south of England coast, following the railway lines. These he lost in the darkness. At 6:35, at an altitude of 1,400 feet, he left the English shore though the precise point is unknown, and a thick fog being on the water, he rose to a greater altitude until the stars were clearly seen, and then set his course, steering by the aid of the heavens. Two hours later he sighted the French coast, and at 8:46 passed over its line. The fog growing thicker, he had to ascend to an altitude of 5,500 feet to secure an unobscured view of the stars. He circled about for some time; but charts and maps having been lost, and the precise position of the aerostat being unknown, he descended at 2 A. M. with the purpose of waiting until daylight to ascertain his position, and then reascending to complete his journey to Paris. A severe gale sprang up, however, and after holding on to the airship, moored in the open, for several hours, it was deflated, the aeronaut resolving to make a fresh attempt to reach Paris from London by airship.

It was only a few weeks ago that Willows came before public notice, when under the cover of night he traveled from Cardiff to London, a distance of 139 miles, which journey was successfully completed. The most interesting feature of his achievements is that the little airship is his own invention, and it possesses many striking and novel features. Through the courtesy of the inventor we are enabled to publish a few details concerning its design, and his various experiments in the evolution of a dirigible balloon.

The problem has occupied his attention for some years past, but it was in 1905 that he built his first practical craft. He erected a large airship shed on a flat open moorland to the east of Cardiff; and the level character of the country, combined with its comparative quietness, rendered it eminently suited to his experiments and trial flights. The first dirigible was built on the spot in its entirety, and followed the usual cylindrical semi-rigid design. It was built of Japanese silk, measured 72 feet in length by 18 feet maximum diameter, giving an elongation of 4 to 1, the cubical capacity being 12,000 cubic feet of hydrogen gas. The ends were not of true semi-spherical form, while the stern end was somewhat sharper than the prow.



THE WILLOWS DIRIGIBLE EMERGING FROM ITS SHED.

The car was suspended beneath the center of the gas bag, was light in construction, though amply strong. It was built up of steel tubing, the vertical section being triangular, braced with steel wire, and it was slung from the envelope by ropes. At the stern a two-bladed propeller of special design was mounted, driven through belt and shafting by a small 7-horse-power two-cylinder gasoline motor. The most striking feature was the novel combined steering and elevating device carried at the prow of the car, and which somewhat resembled two two-bladed propellers mounted slightly one above the other and with their longitudinal axes parallel.

He made six ascents with this dirigible. The novel combined steering and elevating gear was found to answer very efficiently, and proved decidedly superior to the general arrangements of planes to bring about inclination and declination.

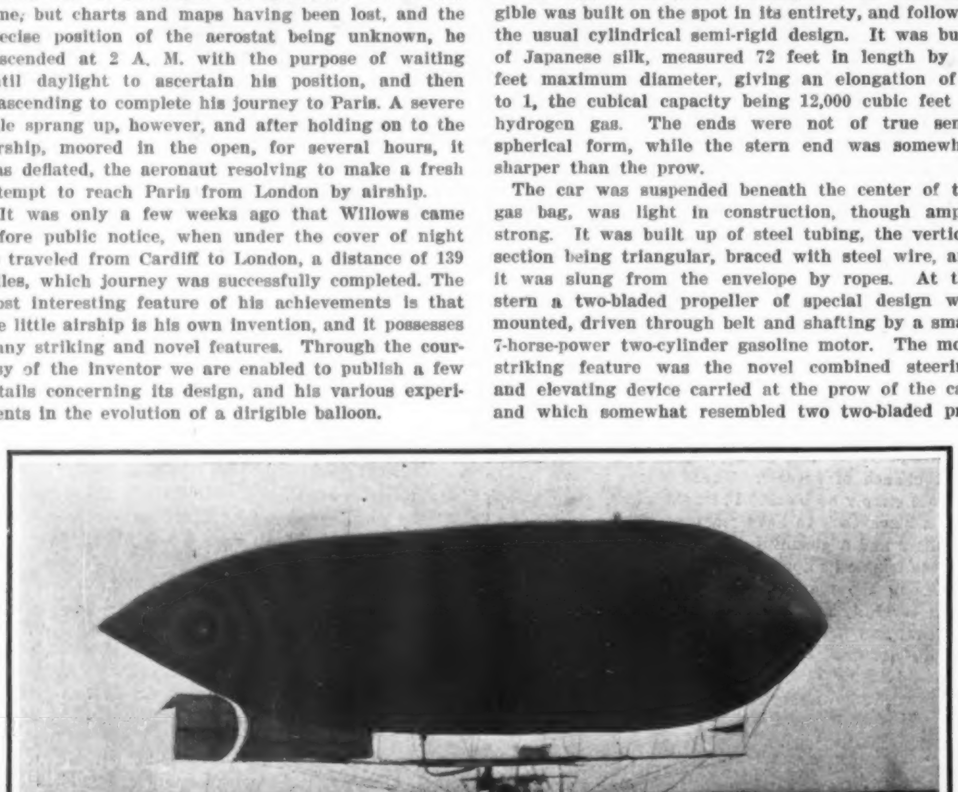
This initial success, which yielded considerable and valuable data, induced him to build the second vessel. It was slightly larger in dimensions, and many modifications suggested in the first trials were incorporated. This dirigible was only submitted to a few short flights to test the value of the improvements and the general efficiency of the design.

He thereupon commenced the construction of the "City of Cardiff," and in this instance adopted the popular fish-shape for the longitudinal profile of the gas envelope. It measures 83 feet in length by 22 feet maximum diameter, giving an elongation of 3.7 to 1, and is of 20,000 cubic feet capacity. The envelope is fitted with ballonet, gas, air, and ripping valves. Another type of suspension was also adopted, so that a small light car could be used, as in the Lebaudy airship. There is a longitudinal boom, 58 feet in length, built up of a tube of steel and two large bamboos. At intervals this boom is fitted with horizontal cross pieces or trees, to the ends of which are attached ropes, by means of which it is slung from the gas bag.

This boom carries the small car, suspended from near the center. The car frame is built up of steel tubing, and carries an eight-cylinder 30-horse-power gasoline motor with a seat for the mechanician. The forward part of the car is entirely free of mechanism, so that the passenger or the observer has a clear outlook on all sides.

Important modifications were effected in regard to the propellers and their disposition on this vessel, as a result of the experience gained on the preceding craft. Instead of a single stern propeller there are two double-bladed propellers mounted on either side of the car, slightly forward of amidships. They are driven through belt and shafting. Another important improvement was the dispensation of the combined horizontal and vertical steering rudder. The rudder for horizontal steering follows the usual broad lines of a plane, and is mounted at the stern; but by means of a patented ingenious device the propelling screws act as the vertical steering rudders, and enable the airship to be driven upward or downward as desired. Such an arrangement appreciably simplifies the mechanism of the airship; eliminates the cumbersome planes for bringing about vertical steering, and represents a distinct saving in weight as well as of resistance to the air.

The rudder for use in horizontal steering is mounted on the extreme end of the longitudinal boom, and there is also a fin or vane, corresponding to the French *empennage*, to insure lateral stability and to keep the balloon to the wind. Each propeller is fitted with a



THE WILLOWS DIRIGIBLE UNDER WAY.

strong guard, so that in the event of a mishap to the screws no damage can be inflicted upon the fabric of the envelope. The aeronaut has the airship under complete command from his seat, and the arrangement is such that the control of motor, valve adjustments, manipulation of ballonet pump, and so forth, can be carried out from that position, and by only one person, so that the second occupant is entirely relieved of all duties in connection with the operation of the vessel.

During the journey to France the only trouble experienced on the part of the aeronaut in connection with the mechanism was in regard to the belt slipping off the ballonet pump. Otherwise there was not the slightest hitch, and Willows is positive that had the weather remained clear, or the maps had not been lost, Paris would have been successfully reached. At all events, he has decided to make another attempt. His effort, however, has conclusively shown that the airship can be successfully navigated at night, which fact enhances its military value.

THE BRIDGE SPANNING THE COPPER RIVER.

AN IMPORTANT ALASKAN STRUCTURE.

BY J. MAYNE BALTIMORE.

During the past few years there has been wonderful railway activity in Alaska Territory, the latest and most important enterprise being the Copper River and Northwestern Line. When completed, this road will be 200 miles long. More than two-thirds of that distance has already been completed and is now in active operation. Work is being crowded forward with all possible speed on the unfinished parts, and the company confidently expect that the entire line will be finished and ready for actual use early next spring.

The construction of this line has involved some vast railway engineering difficulties, owing to the extreme mountainous and precipitous nature of the country through which the new line passes.

One of the great engineering feats accomplished was the construction of the enormous bridge spanning one the Child's Glacier, and the second the Miles Glacier, both in plain view in the bridge illustration.

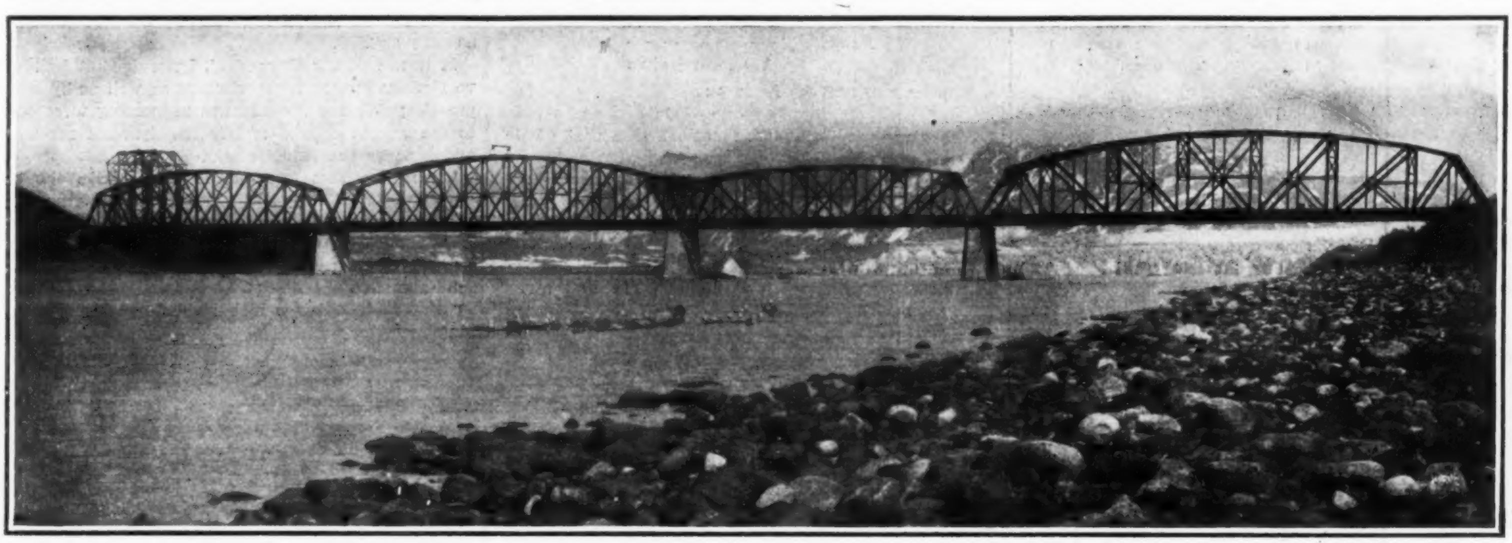
The big bridge, spanning the stream just below these huge glaciers, consists of 1,550 feet of steel resting on three huge concrete piers and two massive abutments, and divided into four camel-back spans. Two of the spans are each 400 feet long; the other two are respectively 300 and 450 feet in length.

In constructing the bridge an early or seasonal start was necessary, owing to the nature of the stream, which has a 14-mile-an-hour current and a rocky bottom. During the winter the ice forms to a depth of six feet. This enabled the piling for the false work to be placed on the river bottom, and it was held firmly in position by the thick ice.

It was absolutely necessary to erect the first two after some months of labor the huge structure was completed. The work was rendered all the more difficult by reason of the two glaciers mentioned.

Miles Glacier is estimated to be more than 50 miles long, 4 miles wide, and 300 feet high. Child's Glacier is nearly 40 miles long, 3 miles wide, and about 300 feet high. It is far more active than the other glacier. This stupendous mass of ice moves forward from one to six feet a day, in warm weather, and is constantly breaking off, the huge bodies falling into the stream with a thunderous roar. Thousands of tons often fall at once, making the earth fairly tremble and throwing the water and small pieces of ice 100 feet or more in the air. It is a magnificent spectacle to watch this glacier in its various phenomena.

The Copper River and Northwestern bridge is the



IMMENSE NEW BRIDGE SPANNING THE COPPER RIVER IN ALASKA.

Under and beyond the spans two vast glaciers are plainly seen at foot of hills.

Copper River—of itself a large and a very strenuous stream. Among other great engineering difficulties that confronted the chief engineer of the road, was the fact that only a short distance above where the bridge crosses the river are two immense glaciers— spans before the ice went out of the stream, so as to be able to erect the big span, which was so designed that it could be cantilevered from the 300-foot span on the other shore span.

Necessarily, the heavy work progressed slowly, but largest and most expensive work of its kind ever carried on in the extreme Northwest, and was constructed as shown under the greatest engineering difficulties. Its total cost approximated half a million dollars.

THE CARBON CONDITIONS OF COMMERCIAL CAST IRON.

Mr. J. E. Stead's address, delivered before the British Association for the Advancement of Science, was devoted to the underlying phenomena connected with the effect of sulphur and silicon on the carbon condition of commercial cast iron. The following embrace his conclusions: (1) The experimental results advanced show proof that carbide of iron in presence of iron sulphide crystallizes with a minute quantity of sulphur not exceeding about one-thousandth part the weight of the carbide, but the nature of the iron-carbon-sulphur compound has not yet been determined. (2) It seems almost, if not absolutely, certain that it is the sulphur crystallized with the carbide which makes the latter stable. (3) The evidence appears to support the view, long held by some, and more recently accepted by others, that during the freezing of iron-carbon-hypo-eutectic alloys after the crystallization of the primary austenite, and in the eutectic and hyper-eutectic alloys, it is the carbide and not graphite which primarily forms, and that the carbide afterward decomposes into graphite and austenite. (4) It has been proved by chemical methods that when the hypo-eutectic alloys, low in silicon, freeze, nearly all the silicon crystallizes out with the primary austenite; and it follows that on gradually increasing the carbon so as to reduce the quantity of primary austenite, the silicon remaining constant, the austenite which does form must be as gradually enriched in silicon up to saturation-point; and, when that point is reached, the excess silicon crystallizes out with a portion of the carbide of iron to form carbo-silicide of iron. Other elements remaining constant, the same result must follow on gradually increasing the silicon. (5) In the alloys of eutectic proportion, and in the hyper-eutectic alloys, as no primary austenite can form, the silicon crystallizes primarily with the carbide. (6) In Cleveland pig-iron containing about 1.5 per cent phosphorus, a ternary eutectic of iron-carbon-phosphorus takes the place of the iron-iron-carbide eutectic. In white irons containing 3 per cent carbon and under 2 per cent silicon, after the primary austenite has fallen out of solution carrying practically all the silicon, it is not iron-iron-carbide which forms, but independent plates of cementite, or carbide of iron, and after these have crystallized, and the residual mother liquor has arrived at the composition of the ternary iron-carbon-phosphorus eutectic, the latter solidifies at 945 deg. C. (1,733 deg. F.). (7) In Cleveland irons which become gray on cooling, and in which there is no primary austenite, the same iron-carbon-phosphorus eutectic is the only eutectic to form during cooling, and, instead of a ternary iron-carbon-silicon eutectic, two independent cementites crystallize—one a silico-carbide, and the other carbide of iron possibly containing a little silicide in solid solution. The micro-examination of the cold alloys, to which a little sulphur had previously been added when the metals were melted, led to the conclusion that it is the carbo-silico-cementite which primarily crystallizes. (8) There is evidence that the primary carbo-silicides are exceedingly unstable, and are the first to decompose into graphite and silico-austenite. (9) In the absence of a sensible quantity of phosphorus, two cementites form—one the silico-carbide cementite, the other the carbide cementite—and these crystallize together as a eutectic mixture. (10) The exact composition of the two cementites has not yet been determined, as no chemical method has been found for their isolation. (11) It is evident that it is the exceedingly unstable character of the silico-carbides which is responsible for the grayness of commercial metals rich in silicon and low in sulphur. (12) Silicide of iron, when heated at 1,000 deg. C. (1,832 deg. F.), with pure white iron free from silicon effects the decomposition of the carbide of the white iron. Based on this observation the hypothesis seems justifiable, in cases where all the silicon present in hypo-eutectic alloys crystallizes out with the primary austenite, that after the carbide has solidified diffusion of the silicide follows, and this leads to the decomposition of the carbide of iron into graphite of iron. (13) Many of the results arrived at by chemical analysis support the hypothetical conclusions of Gontermann, who depended mainly on data obtained by thermal methods of treatment. In conclusion, it will be clear, from what I have stated, that there are many gaps yet to be filled. I hope that the knowledge of this fact will lead others to follow up the research, which is far from complete.

PRACTICE AND THEORY OF AVIATION.—VII.*

THE LEADING AEROPLANES.

BY GROVER CLEVELAND LOENING, A.M.

Concluded from Supplement No. 1821, page 339.

PART B. THE PRESSURE ON PLANES INCLINED TO THE DIRECTION OF THE AIR CURRENT.

THE support of an aeroplane is derived from the pressure of the air on its under surface when moved at an angle with the current of air.

The relation of the pressure of a fluid on an inclined face to that on a normal face was first investigated by Newton in Prop. XXXIV, Bk. II. of his "Principia," and he treats of the subject in the following manner:

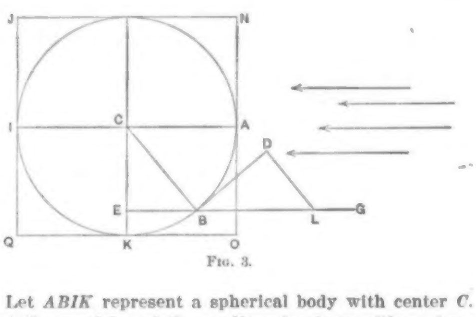


FIG. 3.

Let $ABIK$ represent a spherical body with center C. Let the particles of the medium impinge with a given velocity upon this spherical body in the direction of right lines parallel to AC. Let GB be one of these right lines.

In GB take LB equal to CB and draw BD tangent to sphere at B. Upon KC and BD, let fall the perpendiculars BE and LD. Then a particle of the medium impinges on the globe at B in an oblique direction. Let this force with which it would strike the globe be F. A particle of the medium impinges on the face of the cylinder $ONJQ$ described about the globe with the axis ACI, in a perpendicular direction at B. Let this force be F^1.

Then $F : F^1 = LD : LB = BE : BC$.

The force F tends to impel the globe in direction BC, normal to BD. Let this tendency be T. And let the tendency of the force to move the globe in direction parallel to AC be T^1.

Then $T : T^1 = BE : BC$.

Then joining these ratios if we let $P =$ the pressure exerted on the globe obliquely in the direction GB and $P^1 =$ the pressure exerted on the face of the cylinder, perpendicularly, in the line GB.

$$P : P^1 = BE^2 : BC^2.$$

But BE is the sine of the angle BCE, and therefore sine of angle LBD, which is the angle of incidence of an element of surface to the direction of the wind. We therefore have by the Newtonian theorem, that the pressure of a moving fluid on an inclined surface is proportional to the square of the sine of the angle between the surface and the current.

Navier and Weisbach also advanced this theory with the result that scientists of the highest repute deduced that mechanical flight was practically impossible.

Actual experiment, however, shows that this is absolutely unfounded and that the pressure of an inclined surface varies substantially as the sine of the angle of incidence. The pressure on the inclined surfaces of aeroplanes in use to-day is over 20 times greater than Newton's theorem would indicate, and the difference is more pronounced, the smaller the angle.

The fundamental hypothesis of Newton, that the resistance of the air was due directly to the impact of the particles renders his consideration of this question invalid. It is well known at present that air particles interfere with one another and form characteristic stream lines and vortices with the result that the pressure on the front face of a plane is different from what it would be by Newton's theory and in addition, there is a very strong suction on the back face.

1. FLAT SURFACES.

In 1763 Borda conducted some experiments on flat inclined surfaces, and proposed a formula in which the pressure was made proportional to the sine of the angle of incidence.

Shortly after this, in 1788, Hutton measured the horizontal component of the pressure on inclined planes by means of a small whirling arm, and these experimental results showed distinctly that Newton's theory was at fault. Hutton deduced the ratio of resistance between inclined and normal plates where $a =$ angle of inclination as $\sin a^{1.842 \cos a}$.

* Accepted as thesis for the degree of A.M., Columbia University, June, 1910.

Col. Duchemin in 1842 proposed the formula:[1]

$$P_a = P_{90} \frac{2 \sin a}{1 + \sin^2 a}$$

where P_a is the pressure acting on a plane inclined at angle a with the air current and P_{90} the corresponding pressure on the same plate when placed normal to the current as obtained by the formula:

$$P_{90} = KSV^2$$

Hastings proposed the formula:

$$P_a = P_{90} . 2 \sin a$$

for small angles.

Lord Rayleigh, after investigating this problem,[2] expressed the relation between P_{90} and P_a as

$$P_a = P_{90} \times \frac{(4 + \pi) \sin a}{4 + \pi \sin a}$$

This formula was verified by Stanton in 1902.

Combining both theory and experiment Von Loessl made the pressure on surface inclined directly proportional to the sine of the angle of incidence.[3]

De Louvrie enlarging upon the formula of Duchemin, expressed P_a in terms of P_{90}[4] in the form:

$$P_a = P_{90} \times \frac{2 \sin a \,(1 + \cos a)}{1 + \cos a + \sin a}$$

Luyties suggests the formula:

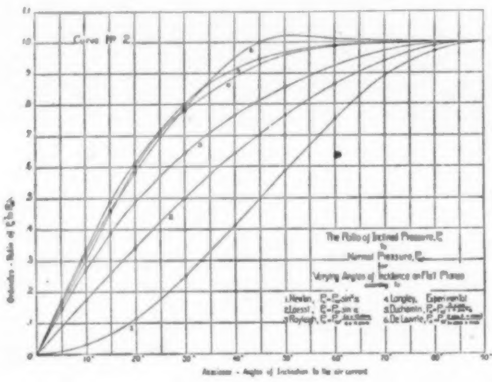
$$P_a = P_{90} \times 2 \sin a - \sin^2 a$$

which gives results almost identical with that of De Louvrie.[5] He further proposes a convenient and accurate enough relation for very small angles, namely:

$$P_a = P_{90} \times \frac{a}{30}$$

A formula of substantially the same form as Hutton's was suggested by Soreau quite recently.[6]

These various formulæ are graphically represented in Curve 2, the difference between the Newtonian formula and the others being quite marked.



CURVE No. 2.

Langley's experiments showed conclusively that the sine squared law was wrong. In the experiments with the resultant pressure recorder,[7] his results show a remarkably close agreement with the formula of Duchemin, as is shown by Table VIII. This practically identifies Duchemin's formula as correct for flat surfaces.

TABLE VIII.

Ratio of $\frac{P_a}{P_{90}}$

Angle of Inclination.	By Langley's Experiments.	By Duchemin's Formula.
5	.15	.17
10	.30	.34
15	.46	.48
20	.60	.61
25	.71	.72
30	.78	.80
35	.84	.86
40	.89	.91
45	.93	.94

We can therefore conclude for flat surfaces that

$$P_a = P_{90} \frac{2 \sin a}{1 + \sin^2 a}$$

where $P_{90} = .003\ S.V^2$.

LIFT AND DRIFT.

If we represent by P_a (Fig. 4) the pressure acting perpendicular to the surface of a plane inclined at an angle a in a wind current of velocity V, we may resolve it into two components at right angles, one acting perpendicularly and equal to L, and another acting horizontally and equal to D.

Then $D = P_a \sin a$

and $L = P_a \cos a$

In the present terminology of Aerodynamics we call L the "lift" and D the "drift" of a plane.

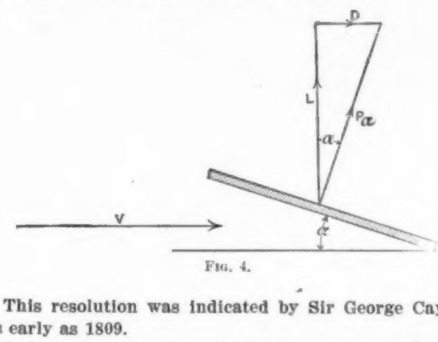


FIG. 4.

This resolution was indicated by Sir George Cayley as early as 1809.

It is not purely theoretical, however, but has been verified by Langley's experiments as well as by actual practice; L being the effective supporting force equal to the weight carried and D the dynamic resistance overcome by the thrust of the propeller.

The ratio of these two quantities L/D, called the ratio of lift to drift, is obviously an excellent means of expressing the aerodynamic efficiency of an aerofoil, and is used as such.

2. CURVED SURFACES.

Langley it is said investigated curved surfaces, but his results have not as yet been published.

Lilienthal strove to imitate the birds, and examined carefully the shape and structure of wings of the various species.[8] He recognized the importance of the shape of wing and found after experiment that even very slight curvatures of the wing profile (in section) considerably increased the lifting power.

In a flat plane the pressure is always perpendicular to the surface and as pointed out above, the ratio of lift to drift is therefore as the cosine to the sine of the angle of incidence.

But in curved surfaces a very remarkable situation is found. The pressure is not uniformly normal to the chord of the arc, but is considerably inclined in front of the perpendicular with the result that the lift is increased and the drift is decreased.

Lilienthal was the first to discover this significant fact and fully set it forth. He says: "When a wing with an arched profile is struck by the wind at an angle a with a velocity V, there will be generated an air pressure P which is not normal to the chord, but is the resultant of a force N, normal to the chord and of another force T, tangential to the chord."

"Then if we call A the area of the wing and 0.005 the constant for air resistance, we get

$N = n \times 0.005 \times A \times V^2$

$T = t \times 0.005 \times A \times V^2$

"Values of n and t show that arched surfaces still possess supporting powers when the angle of incidence

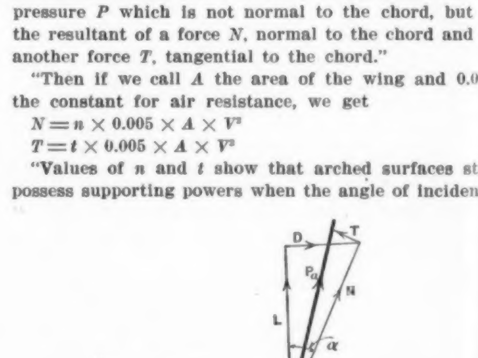


FIG. 5.

becomes negative. The air pressure T becomes a propelling one at angles exceeding 3 deg. up to 30 deg."

As Mr. Chanute has pointed out, this does not mean that there is no horizontal component or "drift" of the normal pressure N, under these conditions, but that at certain angles the tangential pressure T, which

would be parallel to the surface and only produce friction in the case of a flat plane, acts on a curved surface as a propelling force.[9]

The experiments of Wilbur and Orville Wright at Kitty Hawk verified the existence of "Lilienthal's Tangential," and experiments conducted by them later in the laboratory further supported this fact, although their results differed from those of Lilienthal at angles below 10 deg.[10]

Fig. 5 illustrates the resolution of forces on a curved plane L and D being the lift and drift as obtained from the effective pressure N.

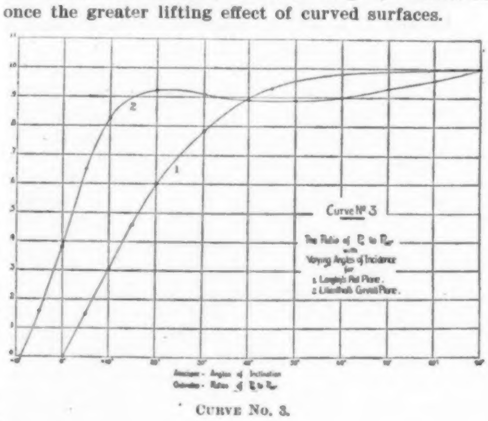
Table IX gives n and t for a surface arched 1/12 at various angles of incidence, as deduced by Lilienthal.

TABLE IX.

Lilienthal's table, 1/12 Curve.

a deg.	n	t	a deg.	n	t
—9	.000	+.070	16	.909	—.075
—8	.040	+.067	17	.915	—.073
—7	.080	+.064	18	.919	—.070
—6	.120	+.060	19	.921	—.065
—5	.160	+.055	20	.922	—.059
—4	.200	+.049	21	.923	—.053
—3	.242	+.043	22	.924	—.047
—2	.286	+.037	23	.924	—.041
—1	.332	+.031	24	.923	—.036
0	.381	+.024	25	.922	—.031
+1	.434	+.016	26	.920	—.026
+2	.489	+.008	27	.918	—.021
+3	.546	.000	28	.915	—.016
+4	.600	—.007	29	.912	—.012
+5	.650	—.014	30	.910	—.008
+6	.696	—.021	32	.906	.000
+7	.737	—.028	35	.896	+.010
+8	.771	—.035	40	.898	+.016
+9	.800	—.042	45	.888	+.020
+10	.825	—.050	50	.888	+.023
11	.846	—.058	55	.890	+.026
12	.864	—.064	60	.900	+.028
13	.879	—.070	70	.930	+.030
14	.891	—.074	80	.960	+.015
15	.901	—.076	90	1.000	.000

Curve 3 shows the variation of the normal pressure on an inclined surface according to Lilienthal (curved), and the same for a flat surface according to Langley. The difference especially for small angles, exhibits at once the greater lifting effect of curved surfaces.



CURVE No. 3.

Lilienthal's values are by no means as exact and accurate as we could desire for use in designing the present type of aeroplane surface, but in view of the lack of any better table, we can with reasonable reservation make use of them.

Wilbur Wright is of the opinion that Lilienthal's values are all somewhat too large at angles below 9 deg.

Though many excellent treatises have been written on the subject, it is hardly possible with the present knowledge of aerodynamics to explain exactly what the significance of these pressures N and T are or to bring them under any well-known set of physical laws.

Wegner von Dallwitz, however, has succeeded in arriving at a mathematical expression of the lift of a curved plane as

$$L = K \cos a \tan^2 a\, S.V^2$$

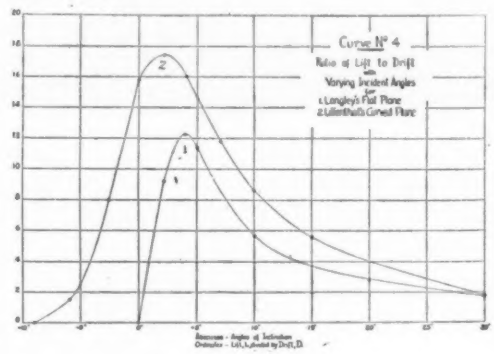
where K is a constant equal to 0.26 when metric units are employed.

An examination of the photographs of stream lines of air obtained by such experimenters as Marey, Hele-Shaw, Mach, and Ahlborn, suggests that a surface with a pronounced curve at the front, would tend, when the current of air is swift enough, to produce a vortex action under the front edge, and recent investigations indicate that such action would increase the dynamic resistance, enormously, as the speed is increased.

For high speeds, therefore, it appears advisable to discard the curved surface that is so widely used at present, and in its stead substitute a surface with a flat under side and a curved upper side, having considerable thickness at the center. The air stream is then "influenced" and guided smoothly over the upper curved face, while the lower flat face permits of a much easier flow, and consequently of a decrease of dynamic resistance or drift. Whether the lift would be proportionately decreased can be determined only by practice. In the racing machines of the near future, however, we can expect to see such surfaces used. Such surfaces however will without doubt tend to give great instability.

3. THE RATIO OF LIFT TO DRIFT.

The ratio of Lift to Drift is of great importance in the design of aeroplanes, and that surface which has the greatest ratio of lift to drift, under working conditions, will be the most efficient from an aerodynamic standpoint, i. e., it carries the greatest weight with the least power.

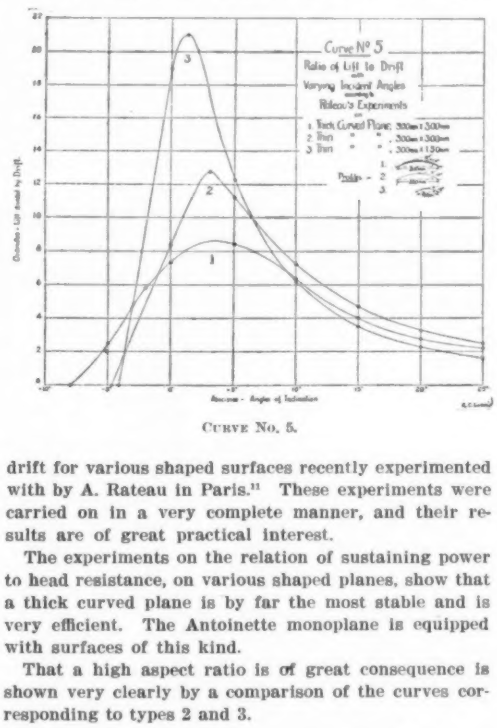


CURVE No. 4.

Curve 4 shows the variation of this ratio with the incident angle for both Langley's flat plane and Lilienthal's arched one.

The difference is most pronounced, and the large value of the ratio for small angles show arched surfaces to be the most economical in flight.

Curve 5 shows the variation of the ratio of lift to



CURVE No. 5.

drift for various shaped surfaces recently experimented with by A. Rateau in Paris.[11] These experiments were carried on in a very complete manner, and their results are of great practical interest.

The experiments on the relation of sustaining power to head resistance, on various shaped planes, show that a thick curved plane is by far the most stable and is very efficient. The Antoinette monoplane is equipped with surfaces of this kind.

That a high aspect ratio is of great consequence is shown very clearly by a comparison of the curves corresponding to types 2 and 3.

References:
[1] Duchemin, "Les Lois de la Resistance des Fluides," Paris, 1842.
[2] Rayleigh, Lord, Manch. Philos. Soc., 1900; Nature, v. 27, p. 534; Smith. Inst. Rep., 1900.
[3] Ritter von Loessl, "Die Luftwiderstandgesetze."
[4] De Louvrie, Ch., Proc. Int. Conference, 1893.
[5] Luyties, O. G., Aeronautics, v. 1, p. 13, No. 3.
[6] Soreau, R., "Nouvelle Formule," Aerophile, v. 17, p. 315.
[7] Langley, "Experiments in Aerodynamics," p. 24.
[8] Lilienthal, O., "Vogelflug als Grundlage der Fliegekunst"; Zeit. für Luft., v. 14, heft 10; Aeron. Annual, No. 3, p. 95.
[9] Chanute, O., "Sailing Flight," Aeron. Annual, No. 3, p. 115.
[10] Wright, W., "Some Aeronautical Experiments," Smith. Inst. Rep. for 1902, p. 145.
[11] Rateau, "Recherches Dynamiques," Aerophile, v. 17, p. 338.

C. THE FRICTION OF THE AIR.

It is well known, from the investigations of Froude and others, that the frictional resistance of a body in water was great. By analogy it would seem as if the friction of the air would also be considerable. Many prominent experimenters and investigators, however, have stated that the tangential resistance of air is negligible.

Langley implicitly assumed the effect of friction at the speeds he used, to be negligible, and did not investigate the problem to any extent.[1]

Clerk Maxwell conducted experiments on the viscosity of the air, i.e., the internal friction of the fluid, and gave the coefficient of viscosity of air as $\mu =$ 0.0001878 $(1+0.0027\,\theta)$, θ and μ being taken as defined in his paper.[2] By this formula the actual tangential force on a plane of one square foot area moving horizontally at 100 feet per second is less than 1/50 of 1 per cent of the pressure on the same plane when moved normally at this speed.

Maxim, Dines, and Kress considered the friction negligible throughout their experiments.[3]

Armengaud and Lanchester, who have thoroughly investigated the subject, take the opposite view and consider skin friction a very appreciable factor in the resistance of an aeroplane.[4]

In 1882 Dr. Pole investigated the skin frictional resistance of the dirigible balloon of M. Dupuy de Lome and found it to be $0.0000477\, d l v^2$ where d is the diameter, l the length, and v the velocity.[5] This gave a very appreciable value to the frictional resistance.

W. Odell in 1903 conducted experiments for the purpose of determining the friction of the air on rotating parts of machines and arrived at the conclusion that the energy dissipated per second $= c\, w^3 v^5$ where c is a constant, w the angular velocity of the disks with which he experimented, and v the radius of the disk.[6] The friction was found to be considerable, although the character of his experiments precludes their being applied directly to aeroplanes.

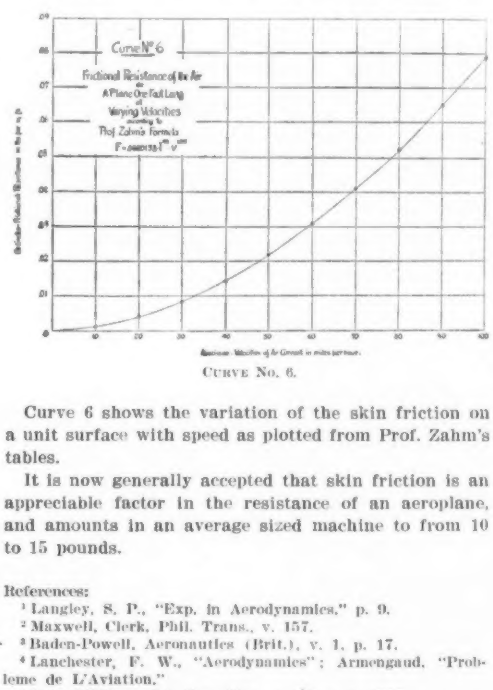
Canovetti found the skin friction on surfaces equal to a constant times the square of the velocity, the constant taking the value 0.00012 when the metric system of units was employed.[7]

The most thorough experiments in this line were conducted by Prof. Zahm in 1903.[8] The results of his experiments showed conclusively that the friction of the air on surfaces was a very considerable factor, and he expressed its general value in the formula:

$$F = 0.0000158\, l^{0.93}\, v^{1.85}$$

where $F =$ the frictional drag in pounds per square foot, $l =$ the length of the surface in the direction of motion in feet, and $v =$ the velocity of the air past the surface in miles per hour.

The friction was found to be approximately the same for all smooth surfaces, but 10 to 15 per cent greater with extremely rough surfaces such as coarse buckram.



CURVE No. 6.

Curve 6 shows the variation of the skin friction on a unit surface with speed as plotted from Prof. Zahm's tables.

It is now generally accepted that skin friction is an appreciable factor in the resistance of an aeroplane, and amounts in an average sized machine to from 10 to 15 pounds.

References:
[1] Langley, S. P., "Exp. in Aerodynamics," p. 9.
[2] Maxwell, Clerk, Phil. Trans., v. 157.
[3] Baden-Powell, Aeronautics (Brit.), v. 1, p. 17.
[4] Lanchester, F. W., "Aerodynamics"; Armengaud, "Probleme de L'Aviation."
[5] Pole, William, Ecl. Eng. Mag., v. 27, p. 1, 1882.
[6] Odell, W., "Experiments on Air Friction," Engineering (London), January, 1904.
[7] Canovetti, "Sur la Resistance de l'Air," Paris, Acad. Sci., v. 144, p. 1030.
[8] Zahm, A. F., "Atmospheric Friction," Bulletin, Phil. Soc. of Wash., v. 14, p. 247.

D. THE CENTER OF PRESSURE ON A PLANE.

Newton implicitly assumed that when a rectangular plate was moved through the air at an angle of inclination to the line of motion the center of pressure and the center of the surface were always coincident. It has long been recognized, however, that this is not the case, and that the position of the center of pressure varies with the incident angle.

Joessel in 1869, was the first to experimentally determine the variation of position of the center of pressure at different angles.[1] His experiments were conducted on square flat planes and he deduced as a result of his experiments, the formulæ:

$$C = (0.2 + 0.3 \sin a)\, L$$
$$d = (0.3 - 0.3 \sin a)\, L$$

where C is the distance of the center of pressure from the front edge of the plane, a is the angle of incidence, L is the width from front to back of the plane, and d is the distance of the center of pressure from the center of surface. These formulæ indicate that the center

of pressure varies from 0.5 to 0.2 of the distance from the front to the center of the plane.

In 1875 Kummer also conducted experiments on the position of the center of pressure.[2] The method of experiment adopted by him consisted essentially in finding the angle of inclination of the plane, corresponding to a series of fixed distances of the center of pressure from the center of figure.

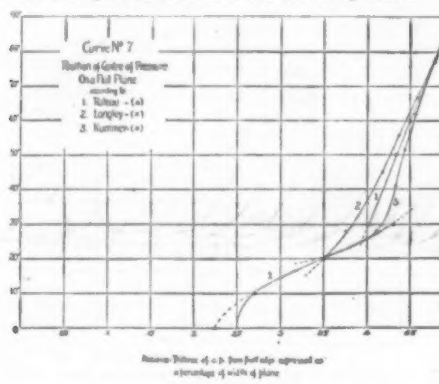
The experiments conducted by Langley with the "counterpoised eccentric plane"[3] were also of this character. Both of these sets of experiments were on flat square planes, and their general results given in Table X show how closely they agree.

TABLE X.

Angle of Plane with Current.	Distance of c. p. from center plane as percentage of side of plane.	
	Langley.	Kummer.
90 deg.	0	0
78 deg.	.021	
77 deg.		.022
67.3 deg.	.042	
62 deg.		.044
55.8 deg.	.063	
52 deg.		.056
45 deg.	.083	
41 deg.		.067
28 deg.	.125	.089
21 deg.		.144
20.5 deg.	.146	

Neither of these experimenters obtained values for very low angles.

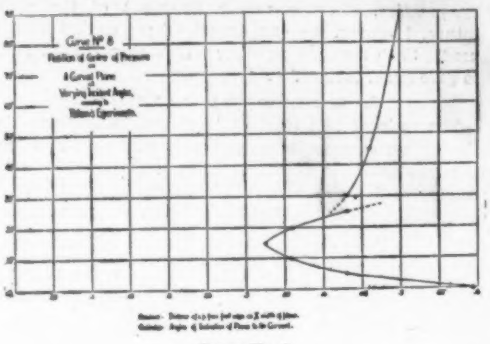
M. Rateau, in the aerodynamic experiments recently conducted by him, investigated the variation of position of the center of pressure on flat planes.[4] His results are shown graphically in Curve 7, and indicate that at 0 deg. and near 30 deg. there are regions of great instability. The results of Langley and Kummer are also plotted on this curve for comparison.



Curve No. 7.

The movement of the center of pressure on curved surfaces is quite different from that on flat surfaces. In deeply arched surfaces the center of pressure moves steadily forward from the center of surface as the inclination is turned down from 90 deg. until a certain point is reached, varying with the depth of curvature. After this point is passed a curious phenomenon takes place; the center of pressure instead of continuing to move forward with decrease of angle, turns rather abruptly and moves rapidly to the rear. According to Wilbur Wright, this action is due largely to the pressure of the wind acting also on the upper side of the arched surface at low angles. The action, however, is unmistakable, and has often been observed in practice.

The experiments of M. Rateau, already alluded to, also included an investigation of the movement of the center of pressure on an arched surface, the results of which are shown graphically in Curve 8. The reversal in movement is very apparent in the neighbor-



Curve No. 8.

hood of 15 deg. and shows strikingly how different the conditions of pressure on a curved surface at low angles, are from those on flat surfaces. A region of instability at 30 deg., however, seems also to be present in a curved surface.

References:
[1]Joessel, Memorial du Genie Maritime, 1870.
[2]Kummer, Berlin Akad, Abhandlungen, 1875, 1876.
[3]Langley, "Experiments in Aerodynamics," Chapt. 8.
[4]Rateau, A., Aerophile, v. 17, p. 330, August, 1909.

E. THE TOTAL RESISTANCE TO AN AEROPLANE.

By far the greatest factor to be dealt with in the design of an aeroplane is the resistance to motion. On its reduction and elimination as far as possible depend the ability to fly, the speed, and the power efficiency.

The total resistance is made up of three parts:

1. The head resistance of the framing and body.
2. The "drift" of the plane or planes.
3. The frictional resistance of the whole.

The determination of each of these parts separately has been considered. It remains to group them together.

From the analysis of "lift" and "drift" it can readily be seen that provided the proper corrections for a curved surface (tangential and normal components) have been made, the Drift D can be represented by the formula

$$D = W \tan \alpha$$

where W = the weight of the machine, balanced by the "lift" and α = the angle of incidence.

We then have, grouping the previous results together, and calling H the combined cross-sectional area of all the wires, struts, framing, and body, l the total length of friction surface, and v the velocity in miles per hour.

$$\text{Total resistance} = 0.0029\,HV^2 + W \tan \alpha + 0.000158\,l^{0.93}\,V^{1.85}.$$

For actual flight this resistance in pounds must be overcome by the thrust or tractive effort of the propeller.

Remedying Defects in Zinc Castings.—A solution of soda in water of 33 deg. Bé strength, and fine precipitated chalk are mixed into a thick plastic paste by thoroughly incorporating zinc dust (zinc gray as it is called). This makes a gray mass that sets in 6 to 8 hours and becomes exceedingly hard. If, after it has hardened, it is polished with an agate burnisher, it assumes the shining white appearance of the metallic zinc.

TRADE NOTES AND FORMULÆ.

Tin Foil Varnish.—Two hundred parts of shellac are dissolved in 1,000 parts alcohol, then filtered. The slime remaining on the filter is allowed to drain, the funnel being covered with a glass plate to prevent, as far as possible, the evaporation of the alcohol. To the shellac varnish thus obtained, add 100 parts of the best white gum elemi and 25 parts of Venice turpentine, and allow it to stand at moderate heat, shaking it up frequently. Then filter it. Press out the residue and add to the filtrate.

Colored Varnish for Tin Articles.—Finely pulverized biacetate of copper, 10 parts; spread it on a slab and allow it to remain for several days in a warm place. The residual powder is then mixed with oil of turpentine, and to this mixture add 100 parts of good copal varnish at a temperature of 212 deg. F. Pour into a glass bottle and allow it to stand for a few days. This gives, with four to five coats, a green, with two coats a gold glistening effect. The color is also different, according to the temperature of the articles.

Light to Dark-Green Enamel-Like Coating for Zinc Articles.—One hundred parts of hyposulphite of soda are dissolved in 800 parts of boiling water, and while stirring, 40 parts of sulphuric acid are poured in. In the hot solution poured off from the sulphur precipitated, the perfectly bright zinc objects are laid. This produces, according to the time they are allowed to remain in it, a light or deep gray coating. The object is washed off with water and dried. By immersion in hydrochloric acid, diluted with 3 parts of water and quickly rinsing off in water, this enamel-like coating loses its brightness and becomes lighter in color. Aqueous solutions of aniline colors, only slightly color on this matted metal, while on the gray bright coating they have no effect. Marble-like effects are produced if the moistened gray metal is treated only in spots by means of a sponge and hydrochloric acid; and after rinsing, while it is still moist, an acidulated solution of blue vitriol is flowed over it. The dried articles should be given a coating of copal varnish.

Non-Phosphorus Ignition Mass for Matches, that will light on any friction surface.—(a) Mass composed of 1.33 parts of Cologne glue, 1.33 parts of gelatine, 16 parts chlorate of potassium, 1.33 parts of dextrine (Ciocome), 34 parts hyposulphite of lead, 6 parts sulphide of antimony, 5 parts peroxide of lead, 5 parts wood charcoal dust, 10 parts of powdered glass, 4 parts saltpeter, 1 part sulphur, 30 parts of water. To produce hyposulphite of lead, dissolve 4 parts of nitrate of lead in a vat, in 12 to 20 parts of hot rain water and 3 parts hyposulphite of soda in another vessel in 9 to 16 parts of water. Pour the latter solution, stirring meanwhile, into the lead solution. The resultant lead precipitate is allowed to settle, the supernatant clear lye is carefully drawn off, filling again with fresh rain water, and repeating this washing four to five times. The precipitate is then either pressed out, dried at not too high a temperature, and pulverized or used in a moist pastry mass for the ignition mixture preparation of the initing mixture. The glue, previously steeped 6 to 8 hours, and the gelatine for half an hour, are to be boiled in the previously stated quantity of water with the dextrine. Into this hot solution, after its removal from the fire, the chlorate of potassium is introduced and completely dissolved. Then the moist hyposulphite of lead, calculated as to dry weight, is stirred in, and then in the order as given above, the remaining substances. The entire mixture must then be very finely ground in an ordinary grinding mill, and used in a luke-warm condition for dipping the match sticks. (b) Chlorate of potassium, 53.8 parts; gum arabic, 10 parts; gum tragacanth, 3 parts; manganese, 6 parts; oxide of iron, 6 parts; glass powder, 12 parts; bichromate of potash, 5 parts; sulphur, 3 parts; chalk of rosin, 1.2 parts. Friction surface: Sulphide of antimony, 5 parts; amorphous phosphorus, 3 parts; manganese, 1.5 parts; glue, 4 parts. Mix together.

TABLE OF CONTENTS.